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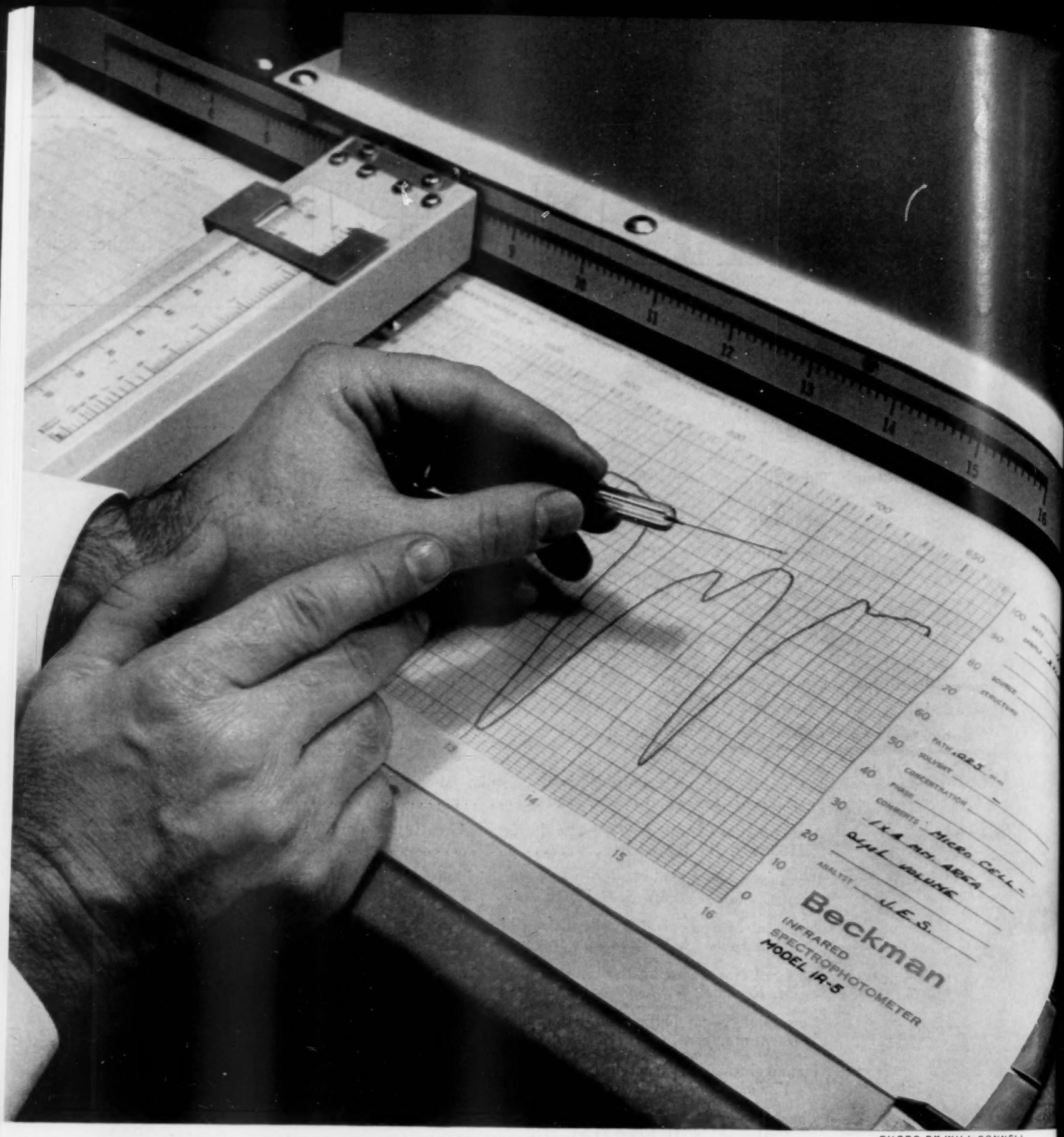

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Straitjacket

"Few would disagree about the necessity for reform in our security system." It was thus that we began our comments on the proposals of the President's Commission on Security last summer [*Science* **126**, 149 (26 July 1957)], and the statement still holds: no action has been taken, no reforms instituted. The issues of security and secrecy have, however, been kept alive by the House Subcommittee on Government Information, which has held several hearings to gather testimony from scientists as well as from present and former Government administrators about barriers to the flow of scientific knowledge. A convenient summary of the hearings and the recommendations of the subcommittee has recently been published under the title "Availability of Information from Federal Departments and Agencies (Scientific Information and National Defense)."

From this report it is clear that the scientists who testified were in agreement on all major points. They were unanimous in condemning multiple clearance as wasteful and ineffective. Each of the Armed Services as well as the Atomic Energy Commission has its own criteria for clearance, and someone who has been cleared by one agency cannot communicate readily with someone who has been cleared by another agency unless he gets clearance from the second agency. The demand for multiple clearance obviously delays the exchange of information between laboratories; it discourages, when it does not completely inhibit, the free discussion of ideas, which scientists generally consider to be an important stimulus to scientific advance; it leads inevitably to duplication of research, for people in one agency may not know what has been done in another.

Another inhibition to the exchange of scientific information is the practice, which is a matter of custom rather than law, subsumed under the rubric "need-to-know." Even a person with appropriate clearance must show a "need-to-know" about the results discovered in another project before he will be given those results. The scientists pointed out that it is difficult for anyone to show a "need-to-know" when he does not know precisely what it is that he might need to know.

The scientists who testified agreed that secrecy was justified in research about weapon applications, but not in basic research. In support of the latter position, they emphasized that nature can answer questions put in any language and that the laws of nature cannot be kept secret: these laws can be discovered in one country as readily as in another. Secrecy in this realm is, they thought, self-defeating.

Although the subcommittee has dealt with other questions, among them the problems of classification and declassification of documents, it has confined its recommendations to the matters discussed above. It recommends the establishment of a system of uniform security clearance, the abolition of the "need-to-know" criterion for scientists who have been cleared, and the cessation of attempts to "hide discoveries of the basic laws of nature made in the past, present, or future."

These are sensible recommendations. If they could be translated into law, science in the Government would be freed from what the subcommittee calls the "straitjacket of excessive secrecy."—G. DuS.

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SCIENCE

The Fallout Problem

It is an example of the interaction between the advances of science and the conditions of society.

Barry Commoner

Not so long ago the impact of science on society was a process to be demonstrated by scholarly research. In the last two decades, however, the effects of rapidly advancing scientific knowledge on public policies have had the lively attention of those responsible for the advances, and since last October 4, this subject has won many new enthusiasts. Ten minutes of research with the morning newspaper will now convince anyone that at least two scientific subjects—investigation of nearby space and nuclear physics—have become the source of major political developments.

Recent events not only demonstrate the intimate interaction between science and social problems; they also show that this relationship is far from harmonious. It is regrettable but true that the very areas of public affairs most closely linked to scientific matters have been marked by misunderstanding, disagreement, and controversy. What has happened in recent months authenticates the warning voiced just a year ago in the report of the AAAS Interim Committee on the Social Aspects of Science: "There is an impending crisis in the relationship between science and American Society. This crisis is being generated by a basic disparity. At a time when decisive economic, political and social processes have become profoundly dependent upon science, the discipline has failed to attain its proper place in the management of public affairs" (*1*).

My purpose here (*2*) is to examine this situation as it is illustrated by one of the more troublesome issues: the long-range effects of world-wide fallout from tests of nuclear weapons.

Fallout

The fallout problem results from the decision on the part of three governments to carry out a particular type of military activity: test explosions of nuclear weapons. It is reasonable to expect these governments to determine that nuclear tests shall not cause inadmissible hazards to human life. This responsibility requires: (i) determination of the need for, and the advantages to be derived from, the nuclear operations; (ii) estimation of the extent and character of the hazards; and (iii) a judgment of the relative weights of the advantages and hazards.

In an orderly state of affairs we expect scientists to produce an evaluation of possible dangers sufficiently clear and sufficiently close to being unanimous to provide a workable basis for decision. We expect the makers of policy to reach a conclusion which represents a balanced evaluation of needs and hazards. We expect the public to be sufficiently informed about the needs and possibly harmful consequences to understand and support this judgment.

This is the ideal. What is the reality?

That governments find advantage in conducting test nuclear explosions may as well be taken here as a fact of political life. It is not our purpose at this time to debate the validity of this need.

As to the scientific aspects of the possible health hazards of fallout, we are fortunate in having the extensive report of the hearings that the Joint Congressional Committee on Atomic Energy held in June 1957, which is now available in two printed volumes of some 2000 pages each (*3*). This report contains the best available summary of the facts, estimates of the variability of the pertinent data, and discussions of the theoretical considerations which bear on the question. The chief facts may be summarized as follows:

Radioactive isotopes contained in the fallout produced by past nuclear tests are being spread throughout the world and increase the radioactivity received by every person on the earth. Since the isotope of chief concern, strontium-90, is relatively long-lived, fallout radioactivity will be perceptible for a few generations even if no further tests occur. Fallout adds to the burden of radioactivity from natural sources, and from medical treatment, to which persons are exposed. Where the relatively low levels of natural radioactivity appear to be agents of disease (as in the case of genetic defects and, probably, leukemia and bone tumors), we may expect the incidence of disease to increase as a result of fallout. The average increased incidence of disease due to fallout from tests conducted thus far will be small (of the order of 0.2 to 2.0 percent) compared with the natural incidence. However, since fallout affects the entire population of the world, the absolute numbers of persons who may become diseased because of its radioactivity are not small. Thus, estimates reported at the Congressional hearings indicate that fallout from past tests may account for the birth of from 2500 to 13,000 genetically defective children and for 25,000 to 100,000 cases of leukemia and bone tumor (considered together) during the next generation. The damage expected from fallout will in most cases not occur until a minimum of about 10 to 30 years has elapsed, and often it will be much later. When the

Dr. Commoner is professor of botany at Washington University, St. Louis, Mo. This article is based on a paper presented at the symposium on radiation hazards of the AAAS Committee on the Social Aspects of Science held at the Indianapolis meeting of the AAAS, 29 Dec. 1957.

damage does occur it will ordinarily be impossible to distinguish between an effect of fallout and effects of natural radiation or other factors. Moreover, any numerical estimate of the average increase in disease incidence expected from fallout must be accompanied by a very large probable error and is subject to considerable regional variation. Finally, the factual and theoretical basis for such prediction is sparse, contains important gaps, and is subject to divergent interpretations.

These are the facts relative to biological hazard that the policy-maker must use to determine whether the testing of nuclear weapons shall continue unabated, shall be diminished, or shall be stopped entirely. How useful to this purpose are these facts?

The recent hearings of the Joint Committee give us a means of testing this question. This committee heard evidence about fallout hazards from some fifty scientists who represented a broad cross-section of the scientific community, both within and outside of the Government. The committee is a group of legislators experienced in the matter of developing policy from facts provided to them by expert testimony. It appears that the evidence presented at the committee's hearing was not sufficient, in their eyes, to dictate policy. This uncertainty is summed up, in the analysis prepared by the Joint Committee after the hearings were concluded, as follows: "There were differences of opinion [i.e., among witnesses] on how to forecast the consequences of further testing" (*4*). The analysis also states: "It is apparent, however, that the people of the world and their governments lack information on the operational problems—meaning information that can be acted upon in a given situation—associated with fallout" (*4*).

Although the Congressional hearings did not consider how the advantages of nuclear testing might be weighed against the estimated hazards, the evidence heard gives us a picture of the size of the problem. Anyone who attempts to determine whether or not the biological hazards of world-wide fallout can be justified by necessity must somehow weigh a number of human lives against deliberate action to achieve a desired military or political advantage. Such decisions have been made before—for example, by military commanders—but never in the history of humanity has such a judgment involved literally every individual now living and expected for some generations to live on the earth.

It is not clear who is expected to make this decision and thereby assume, in an unprecedented degree, the grave moral burden carried by those who must judge the social worth of human life. Should this judgment be made by experts with special competence? If so, where should their expertness lie? In nuclear physics, radiochemistry, biology, medicine, sociology, military strategy? On the other hand, should a responsibility of this weight be reserved to elected officials, in order to ensure that the decisions will reflect the ethical views of our society? At the moment, we seem to have no stated policy in this matter.

Finally, the present situation is also unsatisfactory with regard to the state of public knowledge on the fallout problem. This conclusion could be documented in many ways, but perhaps the most objective and significant view is that contained in the Joint Committee's summary-analysis: "Information on fallout has evidently not reached the public in adequate or understandable ways" (*4*).

Besides being poorly informed, the public has been confused by disagreements among scientists regarding the biological danger of present and anticipated radiation levels from fallout. The public is accustomed to associating science with truth and is dismayed that scientists appear to find the truth about fallout so elusive.

There is, it would appear, some need for improvement in the management of public affairs relative to the problem of fallout. In what follows, I shall discuss some of the reasons that may account for our present difficulties and suggest some possible remedies.

Why Do Scientists Disagree?

Why do scientists disagree in their estimates of the biological hazard of world-wide fallout?

The scientific problem is extraordinarily difficult and complex. Its solution requires an understanding of vast interactions among masses of air, water, and soil and innumerable varieties of plants, animals, and men. Compared with our knowledge of other agencies that affect life, such as light and heat, our knowledge of ionizing radiation is recent. In the scant 60 years since the discovery of radiation, there has not been time enough for biologists satisfactorily to explore its effect on life. Strontium-90, the chief source of fallout radiation, is an element only recently made by man; there has been little time to study it in the laboratory or to analyze the consequences of its intrusion into nature. Finally, the major hazards of radiation—cancer and genetic mutation—are perhaps the most difficult unsolved problems of modern biology. Until the basic causes of these processes become more clear, the effects of radiation will be but poorly understood.

In this situation the available facts are often not sufficient to support or contradict conclusively a given explanatory idea; therefore, opposing theories will for the time flourish together. This accounts for some of the disagreement among scientists' estimates of the probable biological hazard of fallout radiation.

In part, our present troubles derive from the unequal pace of the development of physics and biology. We understand nuclear energy well enough to explode great quantities of radioactive materials into the atmosphere. But our present knowledge of biology and its attendant sciences is not adequate for contending with the difficulties that follow when the radioactive dust settles back to earth.

The remedy is apparent if not easy: more research. Witnesses at the Congressional hearings as well as the earlier report of the National Academy of Sciences radiation committee have emphasized the urgent need for more information. The required research will be costly, and much of it needs to be started at once, before continuing fallout permanently obscures the needed data. Following the recent hearings, the Atomic Energy Commission decided to expand its studies of fallout. But our total effort does not yet either approach the scale demanded by the whole problem or reflect sufficient participation on the part of the university laboratories concerned with basic biological research.

Another source of difficulty is that what *is* known about fallout hazards has not been fully communicated to the scientific community. Originally this problem arose from the association of fallout data with military operations that were closely regulated by security measures. In recent years considerable data on world-wide fallout appear to have been declassified and are now open to free communication among scientists (*5*). Nevertheless, the scientific community has not fully appreciated this change and still takes a gingerly approach to these areas of fact.

All scientists are aware that the spread of man-made radioactive isotopes, especially from fallout, is causing progressive

changes in the radioactivity levels of air, water, soil, milk, and plant and animal tissues. Apart from the matter of possible medical hazards, this process has significant effects on various scientific endeavors, such as dating methods and isotope geology and ecology, and creates many opportunities for new insight into a broad range of terrestrial events. For these reasons, one would think that the spread of radioactivity would be followed closely by the scientific community and that data would be collated systematically with respect to location, origin, and time and published in a form easily accessible to all scientists. This has not yet been done. Of course, the Atomic Energy Commission makes numerous measurements relative to its own activities and supports projects for studying world-wide radioactivity levels in various materials. Some of the results appear in separately published reports, and in occasional papers in scientific journals. But the available information is nowhere brought together in an integrated, graphic form that reaches scientists generally—and especially those with no immediate interest in the information. Without such unified publication, gaps in the present data-gathering activities may go unnoticed and fail to attract the attention of investigators who might otherwise enter into the work.

Such gaps appear to exist. The first intensive survey of the U.S. Public Health Service has been determining radioactive pollution of air at 40 stations throughout the United States for several years. However, the Public Health Service pilot program for a nation-wide survey of radioactivity in milk was begun only in April 1957. The data from this program's monthly analyses of milk from six locations in the United States have not yet been published. Comparably detailed studies of plant and animal tissues do not yet seem to be in the process of being made. Apart from intensive work by the Japanese, we seem to receive relatively little information about radioactivity levels elsewhere in the world. The Atomic Energy Commission reported receipt of the first fallout data from Soviet investigators in December 1957 (*6*).

The inadequacies which decision makers now find in basic and operational information about fallout hazards are, then, in part due to the lack of detailed, integrated, continuing data published in a form capable of enlisting the interest of the entire scientific community in this pervasive problem. We need to recall that the development of a scientific truth is a direct outcome of the degree of communication which normally exists in science. As individuals, scientists are no less fallible than any other reasonably cautious people. What we call a scientific truth emerges from investigators' insistence on free publication of their own observations. This permits the rest of the scientific community to check the data and evaluate the interpretations, so that eventually a commonly held body of facts and ideas comes into being. Any failure to communicate information to the entire scientific community hampers the attainment of a common understanding.

In sum, the fallout question has not yet become an integral part of the freely flowing stream of information which is the vehicle of scientific progress. The remedy is apparent and, for scientists, traditional: more and better publication in readily available journals. Can we not establish a systematic method of continuously reporting integrated information on world-wide levels of fallout radioactivity?

Source of Public Confusion

What is the source of public confusion on the fallout problem? In the past few years, and especially during the last presidential campaign, the public has become aware of a political cleavage on the wisdom of continued testing of nuclear weapons. Political controversy is a natural, expected, and welcome part of public affairs in this country. What appears to trouble the public is not that political opponents have disagreed on the nuclear test issue but that the opinions of scientists have been marshalled on *both* sides of the debate. This appears to violate science's traditional devotion to objectively ascertainable truth.

This division is in part due to the factual uncertainties that have already been discussed, and the public concern may reflect an unawareness of these uncertainties. However, this difficulty results as well from some confusion concerning the scientists' two roles in these matters. As a student and interpreter of nature, the scientist can explain to the public what consequences may result from a given policy that affects nature. As an informed citizen, the scientist has the right and the obligation shared by all citizens to form and express an ethical judgment on the wisdom of enduring that policy. Estimation of the probable damage to health that might result from the continuation of nuclear weapons tests is a scientific question. But there is, I believe, no scientific way to balance the possibility that a thousand people will die from leukemia against the political advantages of developing more efficient retaliatory weapons. This requires a moral judgment in which the scientist cannot claim a special competence which exceeds that of any other informed citizen.

The key word is "informed." Scientists as a group were the first citizens to express opinions on the wisdom of continued testing because they were naturally the first to acquire the facts about the possible hazards of fallout. It is only the lag in the spread of the necessary information to the rest of our citizens that has given the scientists their apparent monopoly on these opinions.

These observations lead to two conclusions. In the first place, scientists must take pains to disclaim any special moral wisdom on this matter. I do not mean to suggest that scientists stop expressing their opinions on this question. On the contrary, so long as the scientists remain the only group well informed about the hazards of fallout, it is essential that they form their judgments, express them, and keep the moral debate before the public. But we must not allow this issue, by default, to rest in the hands of the scientists alone. A question of this gravity cannot be handed over for decision to any group less inclusive than our entire citizenry.

The second conclusion is now self-evident: the public must be given enough information about the need for testing and the hazards of fallout to permit every citizen to decide for himself whether nuclear tests should go on or be stopped. It is the natural task of the scientists and their professional organizations to bring the necessary facts and the means for understanding them to the public. For some years the American Association for the Advancement of Science has recognized this kind of public responsibility, and scientists seem generally ready to assume it.

The National Academy of Sciences report is a good example of what can be done to inform the public about radiation generally. However, that report was only partly concerned with the fallout problem and in this respect is now outdated by the recent Congressional hearings.

What we need now is to marshall the full assemblage of facts about fallout, their meaning and uncertainties, and report them to the widest possible audience. This is not an easy task. It is much

simpler to publicize conclusions alone, and have them accepted not because their factual origin is fully understood but because they carry the authority associated with science.

It seems to me that we dare not take this easy way out. Unless the public has sufficient information to provide a reasonable basis for independent judgment, the moral burden for the future effects of nuclear testing will rest on some smaller group. And no such group alone has the wisdom to make the correct choice or the strength to sustain it. Unless the public is made aware of the gaps and the uncertainties in our present knowledge about fallout, we cannot expect it to support the expensive research needed to minimize them. Without public understanding and support, no government policy can long endure.

Here then is our challenge. Can we, as scientists, with the help of our professional organizations, find a way to inform the public about these great issues? The raw material for such an educational campaign is available in the voluminous report of the Congressional hearings. We can distill from this material the essential facts and ideas and bring them to the people through the media of public communication: radio and television, newspaper articles, and widely distributed pamphlets.

In sum, here are the tasks which the fallout problem imposes upon us. Research into the hazards of fallout radiation needs to be more fully and widely published so that the scientific community will be constantly aware of the changes which world-wide radiation is making in the life of the planet and its inhabitants. This knowledge must be at the ready command of every scientist, so that we can all participate in the broad educational campaign that must be put into effect to bring this knowledge to the public. If we succeed in this we will have met our major duty, for a public informed on this issue is the only true source of the moral wisdom that must determine our nation's policy on the testing—and the belligerent use—of nuclear weapons.

There is a full circle of relationships which connects science and society. The advance of science has thrust grave social issues upon us. And, in turn, social morality will determine whether the enormous natural forces that we now control will be used for destruction—or reserved for the creative purposes that alone give meaning to the pursuit of knowledge.

References and Notes

1. "Social Aspects of Science," Preliminary report of the AAAS Interim Committee, Science 125, 143 (1957).
2. In connection with the preparation of this article, I thank my colleagues of the AAAS Committee on the Social Aspects of Science. I have relied considerably on ideas developed in the course of several committee meetings on the fallout problem.
3. "The Nature of Radioactive Fallout and Its Effects on Man," Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States (Government Printing Office, Washington, D.C., 1957), pts. 1 and 2.
4. "Joint Committee on Atomic Energy, Summary-Analysis of Hearings, May 27–29 and June 3–7, 1957 on the Nature of Radioactive Fallout and its Effects on Man" (Government Printing Office, Washington, D.C., August 1957).
5. It is not clear precisely how much of the existing fallout data is now unclassified. The statement of E. A. Martell at the Joint Committee hearings indicates that cumulative fallout data up to 1 Dec. 1955 obtained by the University of Chicago "Project Sunshine" (under contract to the Atomic Energy Commission) are reported in *Bulletin No.* [illegible] which is classified as "Secret." Data for the period 1 Dec. 1955 to August 1956 are reported in *Bulletin No. 12*, which is unclassified (see *3*, pt. 1, pp. 617, 618).
6. The work of the United Nations Radiation Committee, which is in session at this writing, may be expected to lead to a considerable increase in the amount of world-wide information currently available.

Assimilatory Power in Photosynthesis

Photosynthetic phosphorylation by isolated chloroplasts is coupled with TPN reduction.

Daniel I. Arnon, F. R. Whatley, M. B. Allen

The concept is firmly established in cellular physiology that adenosine triphosphate (ATP) is a universal "energy currency" acting as a link between energy-yielding and energy-consuming metabolic reactions (*1*). It was natural, therefore, that its possible role in photosynthesis, an energy transformation process par excellence, should receive early scrutiny. The participation of ATP in the over-all process of photosynthesis became clear as soon as the enzymatic mechanisms of carbohydrate metabolism were elucidated, when it was recognized that carbohydrates, the main products of photosynthesis, are formed by a series of reactions in which phosphorylation steps with ATP are essential.

The recognition that ATP was needed shed no light on its mode of formation in photosynthesis. That a portion of light energy captured during photosynthesis is transformed into ATP without being first stored in some products of CO_2 assimilation has indeed been envisaged for some time (see review, *2*). What remained obscure was the cellular site at which this special phosphorylation occurred and the mechanism by which it was accomplished. From the standpoint of cellular physiology, the important questions were whether ATP used in photosynthesis was formed by some special light-driven assimilation of inorganic phosphate catalyzed by enzymes closely bound to the chlorophyll system or, in mitochondria, by the mechanism of oxidative phosphorylation.

Direct answers to these questions became possible with the discovery of light-induced ATP synthesis (photosynthetic phosphorylation) first in isolated chloroplasts (*3*) and soon thereafter, by Frenkel, in cell-free preparations of pho-

The authors are, respectively, professor of plant physiology, assistant plant physiologist, and assistant research biochemist, of the University of California, Berkeley. The article is based on a paper presented by Dr. Arnon on 11 Sept. 1957 before the Division of Biological Chemistry of the American Chemical Society at its New York meeting.

tosynthetic bacteria (*4*). Photosynthetic phosphorylation revealed a hitherto unrecognized major site of ATP synthesis in the chlorophyll-containing particles of photosynthetic organisms: chloroplasts in green plants and analogous cytoplasmic particles in photosynthetic bacteria. The mechanism of photosynthetic phosphorylation also appeared to differ, notably in its independence from external molecular oxygen, from ATP synthesis by mitochondria.

The purpose of this article is to assess, on the basis of current evidence, the role of photosynthetic phosphorylation in the over-all process of photosynthesis and, more particularly, to report new evidence which substantially clarifies the relation of light-induced phosphorylations to other photosynthetic events in chloroplasts.

Phosphorylation and Chlorophyll

Prior to the recognition of photosynthetic phosphorylation in chloroplasts, the only cytoplasmic particles known to synthesize ATP were mitochondria. Since green cells contain both types of cytoplasmic particles (*5, 6*), it becomes of interest to compare them as sites of phosphorylation and to appraise their relative importance as sources of ATP in photosynthesis. This will be attempted presently.

In mitochondrial phosphorylation, ATP synthesis is accomplished at the expense of energy released by the oxidation of foodstuffs. The connection between these two events is indirect. The direct effect of the oxidation of foodstuffs is the formation of reduced diphosphopyridine nucleotide ($DPNH_2$). Adenosine triphosphate is formed while $DPNH_2$ is reoxidized in a stepwise manner by molecular oxygen through the mediation of flavoproteins and cytochromes (*7*).

In early models of photosynthetic phosphorylation it was shown that if the reduction of a pyridine nucleotide was carried out by illuminated chloroplasts, the resulting reduced pyridine nucleotide could be used by added mitochondria, from either plant or animal sources, for the generation of ATP by oxidative phosphorylation (*8*). This coupled chloroplast-mitochondrial model system differed from conventional oxidative phosphorylation only in the source of the reduced pyridine nucleotide. In one case DPN was reduced by light, in the other, by a respiratory substrate. The phosphorylation reactions proper, leading to the synthesis of ATP, were in both cases dependent on enzymes localized in mitochondria.

In photosynthetic phosphorylation, isolated chloroplasts were found to be capable of synthesizing ATP without the aid of mitochondria (*3, 9*). When conditions were so arranged that CO_2 assimilation was excluded, chloroplasts used light energy to esterify inorganic phosphate in accord with the over-all reaction:

$$\text{Light} + \text{P} + \text{ADP} \rightarrow \text{ATP} \qquad (1)$$

where P represents orthophosphate and ADP and ATP, adenosine diphosphate and triphosphate, respectively.

In the early experiments photosynthetic phosphorylation occurred only in intact chloroplasts; broken plastids which still retained the green water-insoluble chlorophyll pigments but had lost soluble constituents had only feeble phosphorylating activity (*3, 9*). When in subsequent experiments the phosphorylating capacity was restored to broken chloroplasts by the addition of soluble cofactors such as vitamin K, flavin mononucleotide (FMN), and ascorbate (*9*, p. 6326; *10; 11*), it became clear that the intact structure of whole chloroplasts was not essential to phosphorylation. The enzymes responsible for phosphorylation appeared bound to the water-insoluble chlorophyll pigment system. They were not removed or destroyed by breaking of the chloroplasts but were rendered inactive by the removal of water-soluble constituents (*6, 12*).

The presence of a phosphorylating system tightly bound to the chlorophyll-containing particles is also seen in experiments with cell-free preparations of photosynthetic bacteria. In these organisms there are no chloroplasts, but the photosynthetic pigments are confined to particles termed chromatophores, much smaller in size than chloroplasts (*13*). The experiments of Frenkel (*14*), Williams (*15*), Geller and Gregory (*16*), Geller (*17*), and Mattick and Lindstrom (*18*) with *Rhodospirillum rubrum* and of Anderson and Fuller (*19*) and Newton *et al.* (*20*) with *Chromatium* have shown that in these bacteria the enzymes of photosynthetic phosphorylation are also bound to the particles containing the photosynthetic pigments.

The work with photosynthetic bacteria as well as the recent confirmation of photosynthetic phosphorylation in isolated chloroplasts by Avron and Jagendorf (*21, 22*), Wessels (*23*), Krall and Purvis (*24*), and Chow and Vennesland (*25*) now provides a broad experimental base for the conclusion that in all photosynthetic organisms the cytoplasmic particles which contain the chlorophyll pigments also contain a phosphorylating system. The phosphorylating system differs from the CO_2-fixing enzymes in chloroplasts in being tightly bound to the chlorophyll pigment system; this suggests a close affinity to the early energy transformation reactions. The CO_2-fixing enzymes are water-soluble and are readily removed from the chloroplast (*6, 12, 26*).

Quantitative Importance of Photosynthetic Phosphorylation

Soon after the demonstration of photosynthetic phosphorylation in isolated chloroplasts, attempts were made to compare its rate with that of CO_2 assimilation by illuminated whole cells. Since, as with most newly discovered cell-free reactions, the rates of photosynthetic phosphorylation were rather low, there was little inclination at first to accord this process quantitative importance (*27*) as a mechanism for converting light into chemical energy.

A more reliable estimation of the potential magnitude of photosynthetic phosphorylation became possible with further improvement in experimental methods. Using these, Allen *et al.* (*28*) obtained rates of photosynthetic phosphorylation up to 170 times higher than those originally described (*3*). A comparison of these maximal rates of photosynthetic phosphorylation by spinach chloroplast fragments (500 micromoles of orthophosphate esterified per hour per milligram of chlorophyll) with the maximum rate (*29*) of carbon assimilation by intact leaves (180 micromoles of CO_2 per hour per milligram of chlorophyll) leads to the conclusion that the capacity of chloroplasts to convert light energy into ATP is significant. These high rates of phosphorylation were obtained under conditions when CO_2 fixation was excluded. However, as will be discussed later, chloroplasts are also capable of synthesizing ATP at a high rate when light energy is being used for CO_2 assimilation.

High rates of photosynthetic phosphorylation by isolated spinach chloroplasts have also been reported by Jagendorf and Avron. Under experimental conditions similar to those used by our group, they have obtained rates of 200 micromoles of orthophosphate esterified per hour per milligram of chlorophyll (*22*), but, using a nonphysiological co-

factor (phenazine methosulfate), they have observed rates up to 900 micromoles of phosphate esterified per milligram of chlorophyll per hour (*30*).

It appears therefore that nature has evolved a major mechanism for converting light into useful chemical energy, even under conditions when CO_2 assimilation is curtailed or stopped altogether. The possible physiological significance of this type of energy conversion will be discussed later.

From the standpoint of conventional photosynthesis, the main interest is in those mechanisms for ATP synthesis which can serve not as alternatives but as aids in CO_2 assimilation. The following considerations would suggest that these mechanisms also reside in chloroplasts rather than in mitochondria, which are the major site of ATP synthesis in respiration. (i) The rates of phosphorylation by chloroplasts are, on a nitrogen basis, several times greater than those reported in the literature for oxidative phosphorylation by mitochondria from either plant or animal sources (see *28*). (ii) There is a paucity of mitochondria in leaves. The mesophyll of leaves, which contains most of the chloroplasts, is a tissue remarkably specialized for photosynthesis (*31*). Within the mesophyll cells, especially in the palisade parenchyma, chloroplasts are the dominant cytoplasmic bodies; mitochondria are relatively few in number (*32*). On this basis alone, the contribution of mitochondria to the total ATP requirement in photosynthesis would not be expected to be large (*6, 33*).

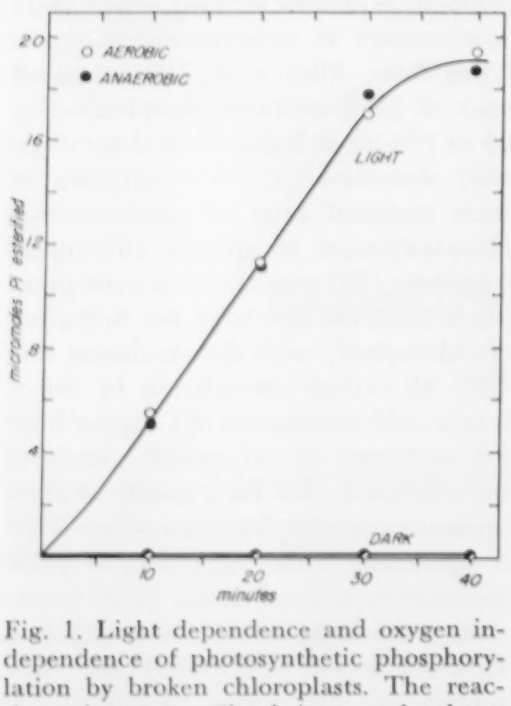

Fig. 1. Light dependence and oxygen independence of photosynthetic phosphorylation by broken chloroplasts. The reaction mixture contained, in a total volume of 3 ml, "broken" chloroplasts (chlorophyll content 0.5 mg), and, in micromoles: tris(hydroxymethyl)aminomethane, *p*H 7.4, 40; adenosine-5-phosphate, *p*H 7.4, 10; potassium phosphate (containing P^{32}), *p*H 7.2, 20; $MgCl_2$, 10; sodium ascorbate, 10; flavin mononucleotide (FMN), 0.01; and vitamin K_5 (2-methyl-4-amino-1-naphthol hydrochloride), 0.3. The reaction was carried out at 15°C under nitrogen or air. Phosphorylation was measured as described previously (*9, 36*).

This assessment of the quantitative importance of ATP synthesis by chloroplasts is reached from measurements of rates of phosphorylation in cell-free systems. A different conclusion about the importance of photosynthetic phosphorylation to the over-all process of photosynthesis was recently reached by Kandler (*34*) from experiments with whole cells. However, in these, the estimation of the rate of photosynthetic phosphorylation can only be made indirectly, since it is difficult if not impossible to isolate, with certainty, from the over-all phosphorus metabolism of the intact cell, those phases which are solely linked to photosynthetic events.

Independence from Molecular Oxygen

In view of the strict dependence of mitochondrial phosphorylation on oxygen (*1, 8*), one of the most striking features of photosynthetic phosphorylation is its independence from molecular oxygen. This was perhaps to be expected for cell-free particles of the photosynthetic bacteria mentioned earlier, since in *Rhodospirillum rubrum* normal photosynthesis proceeds anaerobically without any evolution of oxygen, and *Chromatium* is an obligate anaerobic photoautotroph. It was wholly unexpected, however, in chloroplasts of such an eminently aerobic plant as spinach.

The independence from oxygen of photosynthetic phosphorylation by chloroplasts was not apparent in the early experiments (*3*) prior to the identification of the required cofactors of phosphorylation (*9*, p. 6326; *10; 11*). In later experiments, photosynthetic phosphorylation proceeded anaerobically at rates in no case lower, and in many cases substantially higher, than those observed aerobically, but only when the requisite cofactors of phosphorylation were added. The indepedence of photosynthetic phosphorylation from molecular oxygen, shown in Fig. 1, was established by manometric experiments. This conclusion has recently received strong support from the experiments of Krall *et al.* (*35*) with labeled oxygen.

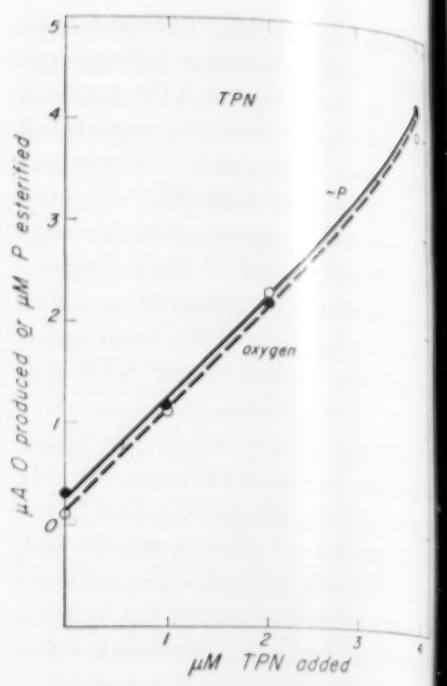

Fig. 2. Stoichiometry of oxygen evolution and adenosine triphosphate (ATP) formation resulting from the photochemical reduction of triphosphopyridine nucleotide (TPN). The relation between moles of TPN reduced, moles of orthophosphate esterified, and atoms of oxygen produced is 1:1:1. The reaction mixture contained, in a final volume of 3 ml., "broken" chloroplasts, (R_{1s}) containing 0.25 mg of chlorophyll, chloroplast extract (CE) equivalent to 2 mg of chlorophyll, and the following, in micromoles: tris, *p*H 8.3, 80; $MgCl_2$, 5; ADP, 10; $K_2HP^{32}O_4$, 10; NaCl, 35; and TPN as indicated. The reaction was run at 15°C for 33 minutes, at which time the reduction of TPN was complete. Oxygen evolution was measured manometrically under nitrogen, and the esterification of inorganic phosphate was measured as described previously (*36*).

Since chloroplasts are able to evolve molecular oxygen in light, it may be useful to define with more precision what we mean by independence from molecular oxygen. We mean that the synthesis of ATP by illuminated chloroplasts occurs (i) when absorption of molecular oxygen cannot be detected either by manometric techniques or by a mass spectrograph (*35*) or, (ii) in an atmosphere of nitrogen or argon when conditions are so arranged that traces of oxygen originally present or formed during the reaction are eliminated (*10*). The possibility that a portion of the oxygen generated in photosynthetic reactions may be immediately consumed in back reactions, before it escapes into the gas phase, is further considered unlikely since chloroplasts are unable to carry out the mitochondrial type of phosphorylation with appropriate substrates or reduced pyridine nucleotides when supplied with oxygen in the dark (*2, 6, 36*).

The independence of photosynthetic

phosphorylation from oxygen had certain general implications. First, it distinguished at once between the light-dependent phosphorylation by chloroplasts and the oxidative phosphorylation by mitochondria and suggested that, in the two kinds of cytoplasmic particles, different enzyme systems were involved in at least some of the intermediate steps in ATP synthesis. Second, it pointed to another fundamental similarity in the photosynthetic mechanisms between photosynthesis in aerobic green plants and anaerobic bacteria, in addition to the photodecomposition of water envisaged by van Niel (*37*).

From the standpoint of photosynthesis in green plants, an interesting question was whether ATP synthesis by chloroplasts is compatible with oxygen *evolution*, which normally accompanies CO_2 assimilation in isolated chloroplasts (*5, 38*), as in intact leaves. Evidence for photosynthetic phosphorylation accompanied by oxygen evolution has recently been obtained (*39, 40*). Since the new work clarifies and modifies the previous concept of photosynthesis by chloroplasts (*5, 6, 36*), it will now be examined in more detail.

Generation of Assimilatory Power

Role of pyridine nucleotides. Di- and triphosphopyridine nucleotides (DPN and TPN) were found to enhance CO_2 fixation by isolated chloroplast fragments (*26, 12*), but experiments to test their participation in photosynthetic phosphorylation had previously yielded only negative results (*5, 6, 12, 26*). Diphosphopyridine nucleotide occupies a key position in oxidative phosphorylation by mitochondria as the hydrogen or electron carrier in oxidations which lead to phosphorylation. The lack of response to added DPN was therefore regarded in earlier discussions (*2, 5, 6*) as another feature which distinguished photosynthetic from oxidative phosphorylation. The lack of response to added TPN was not considered significant, since TPN, unlike DPN, was known to be incapable of serving as a hydrogen or electron carrier in phosphorylation by mitochondria (*41*).

More recently, by changing experimental conditions, we have obtained evidence that TPN, but not DPN, is a catalyst of photosynthetic phosphorylation (*39*, also compare *42*). Substrate amounts of TPN were reduced, and this was accompanied by the evolution of oxygen in accordance with reaction 2. This reaction also requires a TPN-reducing factor which we have identified in an aqueous extract of chloroplasts (CE).

$$2TPN + 4H_2O \xrightarrow[\text{chloroplasts} + CE]{\text{light}} 2TPNH_2 + O_2 + 2H_2O \quad (2)$$

In the presence of adenosine diphosphate (ADP) and orthophosphate (P), reaction 2 was coupled with the formation of 2 moles of ATP. The over-all reaction is summarized by reaction 3:

$$2ADP + 2P + 2TPN + 4H_2O \rightarrow 2ATP + O_2 + 2TPNH_2 + 2H_2O \quad (3)$$

Under appropriate experimental conditions, which will be described elsewhere, the evolution of 1 mole of oxygen was accompanied by the reduction of 2 moles of TPN and the esterification of 2 moles of orthophosphate.

Reaction 3 and Fig. 2 describe a new type of photosynthetic phosphorylation. One mole of orthophosphate is esterified for each mole of TPN reduced. Only part of the light energy absorbed by chlorophyll in this reaction is trapped in the pyrophosphate bond of ATP; the remainder is used for the formation of $TPNH_2$. Thus, the light reaction in chloroplasts consists of the generation of what has previously been termed "assimilatory power" (*2*), accompanied by the evolution of oxygen. Assimilatory power has two components, both of which are needed for the assimilation of CO_2: the reductant $TPNH_2$ and ATP.

The stoichiometry of reaction 3 (Fig. 2) shows that the evolution of 1 mole of oxygen and the synthesis of 2 moles of ATP accompanies the generation of four hydrogen equivalents which are required for the reduction of 1 mole of CO_2 to the level of carbohydrate

$$\begin{array}{c} | \\ [CH(OH)] \\ | \end{array}$$

Reaction 3 would thus account for the well-known photosynthetic ratio CO_2/O_2 of 1, also observed with isolated chloroplasts (*5, 38*), when CO_2 is assimilated to the level of carbohydrate. A general scheme of photosynthesis in chloroplasts, based on these findings, is shown in Fig. 3.

The concept of photosynthesis by chloroplasts represented by Fig. 3 shares certain similarities with, but also differs from, the earlier one which it now replaces (*5, 6, 26, 36*). It is similar in that the chloroplast is regarded as a complete photosynthetic unit containing multienzyme systems divided into three main groups, each controlling an increasingly complex phase of photosynthesis: photolysis of water, photosynthetic phosphorylation, and CO_2 fixation. Carbon dioxide fixation remains, as before, at the apex of this hierarchy and requires the participation of all three groups of enzymes. But photolysis of water is now

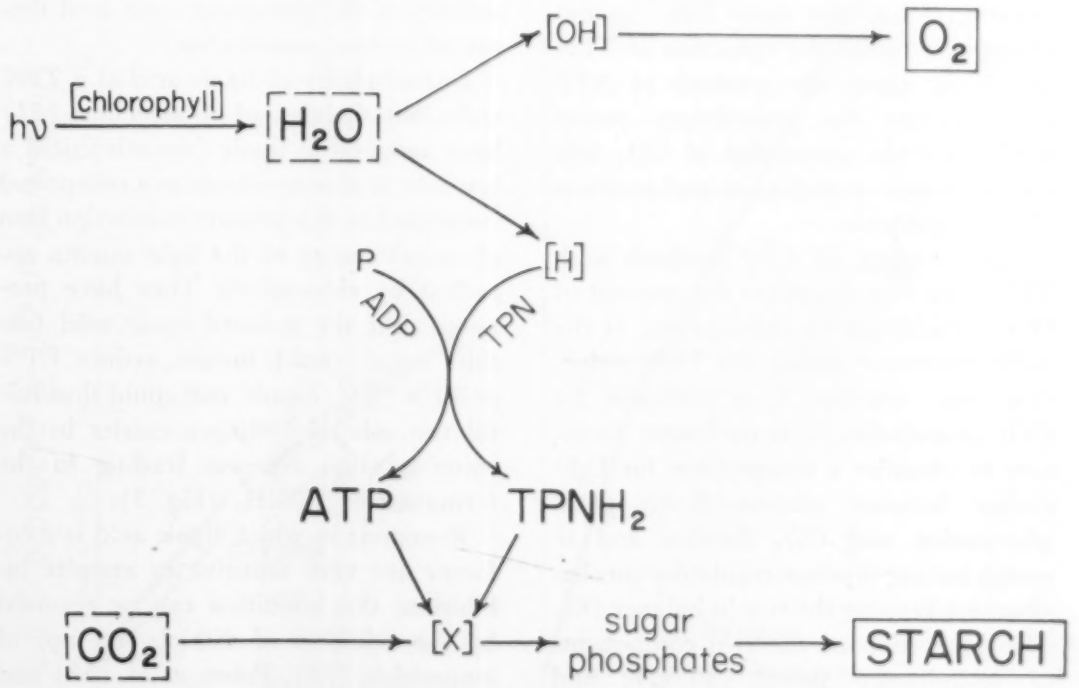

Fig. 3. Scheme for photosynthesis by isolated chloroplasts. Photolysis of water results in the evolution of oxygen and the generation of "assimilatory power" comprising two components: reduced triphosphopyridine nucleotide ($TPNH_2$) and ATP. Assimilatory power is then used for the assimilation of CO_2 in reactions independent of light. [The intermediate *X* in this scheme is not designated as phosphoglyceric acid, as would be demanded by the theory of Calvin (*43*). Experiments on carbon fixation with isolated chloroplasts have so far yielded no unequivocal evidence on this point (*26, 38*; also compare *27*, p. 294).]

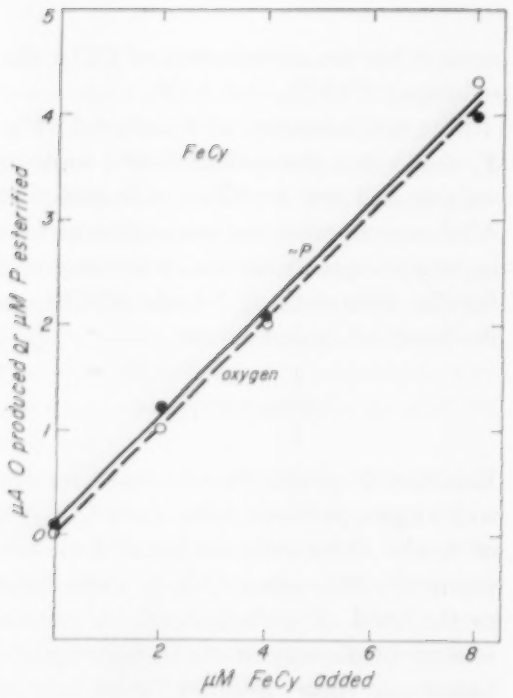

Fig. 4. Photophosphorylation and oxygen evolution with ferricyanide. The stoichiometric relation between moles of ferricyanide reduced, moles of orthophosphate esterified, and atoms of oxygen produced was 2:1:1. The reaction mixture contained, in a final volume of 3 ml, "broken" chloroplasts (P_{1s}) containing 0.1 mg of chlorophyll and the following, in micromoles: tris, *p*H 8.3, 80; $MgCl_2$, 5; ADP, 10, $K_2HP^{32}O_4$, 10; NaCl, 35; and ferricyanide as indicated. The reaction was run at 15°C for 18 minutes, at which time the reduction of ferricyanide was complete.

no longer regarded as resulting *either* in the synthesis of ATP *or* in the reduction of CO_2. Adenosine triphosphate synthesis is *coupled* with the formation of the reductant ($TPNH_2$) required for CO_2 fixation. Thus, the same light quanta which accomplish the reduction of TPN also bring about the synthesis of ATP and generate the assimilatory power needed for the conversion of CO_2 into carbohydrates or analogous end-products of photosynthesis.

The coupling of ATP synthesis with TPN reduction simplifies the concept of CO_2 assimilation by chloroplasts. If the ATP generated during the TPN reduction step (reaction 3) is sufficient for CO_2 assimilation, it is no longer necessary to visualize a competition for light energy between photosynthetic phosphorylation and CO_2 fixation and to search for appropriate regulatory mechanisms for keeping the two in balance (*6*). The generation of the two components of assimilatory power, $TPNH_2$ and ATP, goes up and down simultaneously, in accordance with the rate of CO_2 fixation.

Specificity of TPN. The specificity of TPN in photosynthetic phosphorylation (*39*), together with its previously demonstrated effect on CO_2 assimilation by isolated chloroplasts (*12, 26*), argues in favor of TPN, rather than DPN, as the pyridine nucleotide *directly* associated with photosynthesis [indirectly, of course, DPN could also be effective in the presence of transhydrogenase (*43*)].

The preference for TPN rather than DPN in photosynthetic events was hitherto not well established. It was tied to the phosphoglyceric acid theory of carbon assimilation (*44*) and rested on evidence for the cyclic emergence of light-induced TPN-dependent enzymes (*45*) concerned in the metabolism of that acid: glyceraldehyde-3-phosphate dehydrogenase (GPD) (*46–48*) and glyceraldehyde-3-phosphate-TPN reductase (GTR) (*49*).

The GTR enzyme is known only to oxidize glyceraldehyde-3-phosphate irreversibly to phosphoglycerate (*49*); the emergence of this enzyme in photosynthetic tissue would thus support not the phosphoglyceric acid theory of Calvin (*44*) but rather Warburg's view (*50*) that phosphoglyceric acid is a product of carbohydrate degradation during photosynthesis. The TPN-dependent GPD enzyme which can reduce phosphoglyceric acid offers no compelling evidence for the role of TPN in photosynthesis, since the same function could be performed by the DPN-specific GPD also present in green cells (*46–48*). However, its specificity in photosynthetic phosphorylation, apart from its other conceivable functions, gives TPN a direct role in photosynthesis, regardless of the validity of the phosphoglyceric acid theory of carbon assimilation.

Improbability of lipoic acid as a TPN reductant. Calvin and his associates (*51*) have assigned to lipoic (thioctic) acid a key role in photosynthesis as a compound concerned in the primary conversion into chemical energy of the light quanta absorbed by chlorophyll. They have proposed that the reduced lipoic acid (dithiol form) could, in turn, reduce DPN or TPN (*52*). Lipoic acid could thus fulfill the role of hydrogen carrier in the water-splitting reaction leading to the formation of $TPNH_2$ (Fig. 3).

Reactions in which lipoic acid is a cofactor are very sensitive to arsenite inhibition; the inhibition can be reversed by the addition of dithiols but not of monothiols (*53*). Peters *et al.* (*53*) and Gunsalus (*54*) observed inhibition of the pyruvic oxidation system by concentrations of arsenite of the order of $3 \times 10^{-5} M$; the inhibition was reversed by the dithiol 2,3-dimercaptopropanol (BAL) but not by the monothiol glutathione. In the chloroplast system, 10^{-4} arsenite failed to inhibit the TPN reduction and its coupled phosphorylation. It seems unlikely, therefore, that lipoic acid is a cofactor in this reaction. The TPN reduction and its coupled photophosphorylation are sensitive, however, to other sulfhydryl inhibitors, as is evidenced by their inhibition by *p*-chloromercuribenzoate, an inhibition which was reversed by glutathione.

The improbability that lipoic acid is a participant in photosynthetic photophosphorylation is also indicated by the results of Geller (*17*): $10^{-2} M$ arsenite failed to inhibit phosphorylation by illuminated particles of *Rhodospirillum rubrum*.

Hill reaction as a fragment of a photophosphorylating system. Isolated chloroplasts are known (*55*) to evolve oxygen when they are illuminated in the presence of an artificial electron acceptor (Hill reaction) in accordance with reaction 4, in which *A* represents a nonphysiological substance such as ferricyanide or benzoquinone (*56*).

$$\text{Light} + A + H_2O \rightarrow H_2A + \tfrac{1}{2}O_2 \quad (4)$$

The finding of a phosphorylation which is coupled with TPN reduction and oxygen evolution permits us to view the Hill reaction as a measure of photochemical electron transport which is proceeding without its normally associated phosphorylation reaction. The Hill reaction would thus be analogous to those electron transport reactions studied in particulate systems of animal origin.

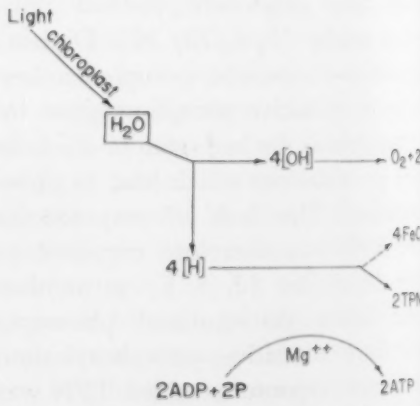

Fig. 5. Diagram representing the generation of "assimilatory power" and the evolution of oxygen by isolated chloroplasts. The components of assimilatory power are reduced triphosphopyridine nucleotide ($TPNH_2$) and adenosine triphosphate (ATP). In the absence of carbon dioxide, $TPNH_2$ and ATP can be generated in substrate amounts in the light by the green fraction of chloroplasts and used subsequently for sugar synthesis in the dark by a colorless chloroplast extract supplied with CO_2 (*72*). (Compare also Figs. 2, 3, and 4.)

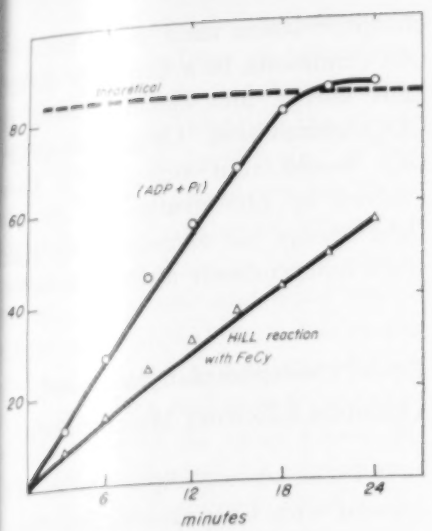

Fig. 6. Effect of phosphate acceptor system on the Hill reaction with ferricyanide. The reaction mixture contained, in a final volume of 3 ml, "broken" chloroplasts (P_{1s}), containing 0.1 mg of chlorophyll; and the following in micromoles: tris(hydroxymethyl)aminomethane, 80; sodium chloride, 35; potassium ferricyanide, 15. The vessel with the phosphate acceptor system received, in addition (in micromoles): ADP, 10; K_2HPO_4, 10; and $MgCl_2$, 5. The oxygen evolution was measured manometrically at 15°C. Gas phase, nitrogen; KOH in the center well of the vessel. Illumination as described previously (*38*).

which oxidation has been separated from its normally associated phosphorylation—for example, in the Keilin-Hartree preparations (*57*) or in the electron transport particles of Green (*58*).

The validity of this hypothesis was tested with a Hill reagent which is compatible with the phosphorylating activity of chloroplasts. Quinone was found not to fulfill this requirement well, but ferricyanide did. Fig. 4 shows the esterification of inorganic phosphate coupled with oxygen evolution and the reduction of ferricyanide by illuminated chloroplasts. The stoichiometry of this reaction is the same as in the case of TPN: 1 mole of oxygen is evolved and 2 moles of orthophosphate are esterified in a transfer of four electrons to ferricyanide (compare with reaction 3 and Fig. 2).

The phosphorylation coupled with the photochemical reduction of ferricyanide can thus be regarded as a nonphysiological model for the generation of assimilatory power (Fig. 5). (The TPN-reducing factor in chloroplast extract is not required for the reduction of ferricyanide.)

Further support for the proposal that the Hill reaction is part of an uncoupled phosphorylation system is seen in Fig. 6. With ferricyanide as a reductant, the rate of oxygen evolution in the Hill reaction was increased by coupling it with phosphorylation. It seems reasonable to interpret this effect as indicating that the electron transport system of chloroplasts is able to function more effectively when it is coupled, as it would be under physiological conditions, to the synthesis of ATP.

Cyclic Photophosphorylation

In measuring the generation of assimilatory power, the phosphorylation coupled with the reduction of TPN was accomplished without the addition of either flavin mononucleotide (FMN) or vitamin K, both of which have previously been identified as cofactors of photosynthetic phosphorylation (*10, 11*). The addition of catalytic amounts of either FMN or vitamin K altered the system profoundly. The results are shown in Figs. 7 and 8.

Phosphorylation was sharply increased, whereas oxygen evolution and the accumulation of reduced TPN were abolished. The most direct explanation of these results is that the addition of catalytic amounts of either FMN or vitamin K brought about additional phosphorylation accomplished at the expense of energy liberated by the reoxidation of $TPNH_2$ by [OH], the oxidized product of photodecomposition of water.

Expressed in another way, the addition of either FMN or vitamin K has brought about a recombination of the photodecomposition products of water, [H] and [OH], and a conversion into ATP of all of the light energy originally trapped in the "water-splitting" reaction. Under these conditions, when CO_2 assimilation did not occur, the hydrogen atoms which would have been used in the reduction of CO_2 became a part of a reconstituted water molecule instead of a newly formed sugar molecule. This type of light-induced phosphorylation is the same as we reported previously under the general name of photosynthetic phosphorylation (*2, 5, 6, 10, 26*). It will now be designated by the more specific name of *cyclic photophosphorylation* (Fig. 9) to distinguish it from the "one-step" phosphorylation associated with the generation of assimilatory power when only part of the captured light energy is converted into ATP (Fig. 5).

Another explanation of the observed effects of FMN and vitamin K on the "one-step" phosphorylation is possible, and is being tested experimentally, but it appears at this time to be unlikely. It would limit phosphorylation only to the electron transfer step coupled with TPN reduction and would explain the increased phosphorylation which follows the addition of FMN or vitamin K (Figs. 7 and 8) as resulting from a more rapid turnover of the TPN rather than

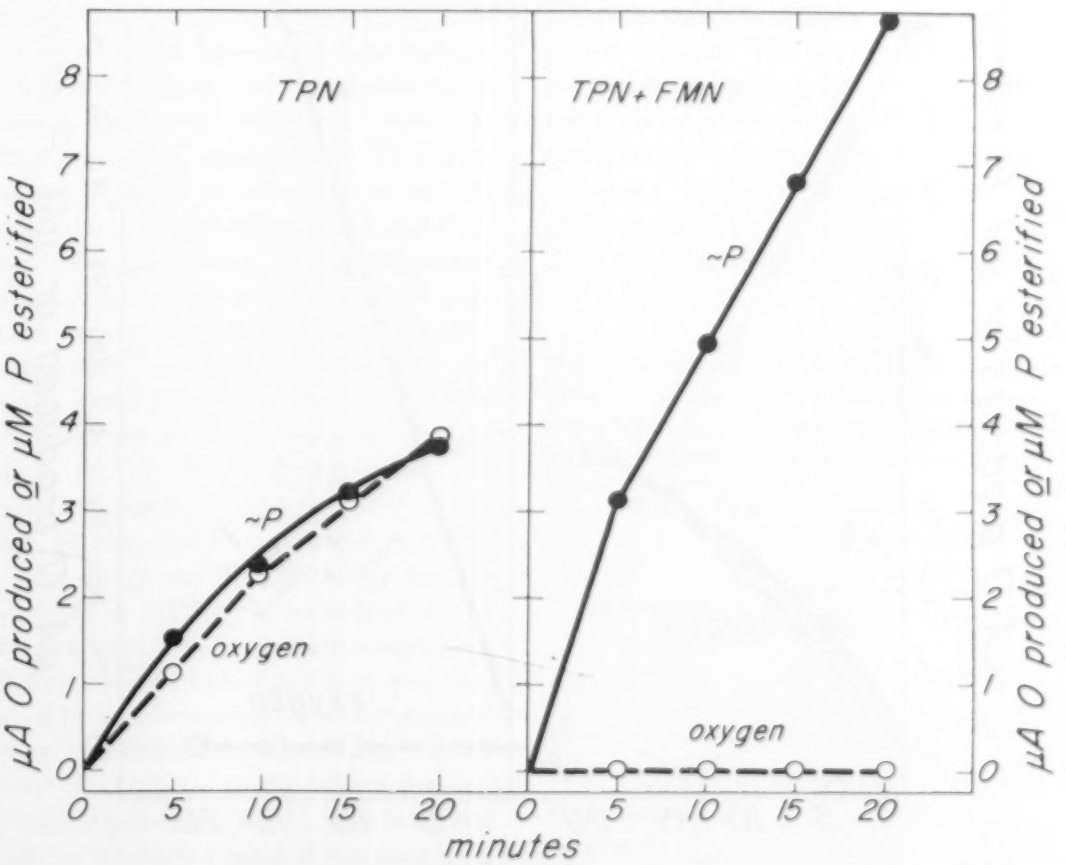

Fig. 7. Photophosphorylation and oxygen evolution with TPN in the presence and absence of FMN. The reaction mixture was the same as that described in Fig. 2, except that 15 μmole of K_2HPO_4, 15 μmole of ADP, and 4 μmole of TPN were used in each vessel. In the "TPN + FMN" series, 0.1 μmole of FMN was added.

from the activation of additional phosphorylation sites.

Physiological significance. In previous discussions (*5, 6, 26, 36*), cyclic photophosphorylation was regarded as the sole photosynthetic phosphorylation and its physiological significance was sought in its contribution of ATP to CO_2 assimilation. The identification of a second type of photosynthetic phosphorylation, as a component of assimilatory power, renders the earlier interpretation of cyclic phosphorylation too narrow.

It is tentatively proposed that another physiological role of cyclic photophosphorylation might be the conversion of light energy into ATP under conditions when CO_2 assimilation is, for one reason or another, reduced or even stopped altogether. This might arise during the well-known midday closure of stomata in leaves of higher plants (see *59*) when the supply of CO_2 becomes restricted. The midday closure of stomata often occurs as a result of a water deficit in the plant. Cyclic photophosphorylation, unlike CO_2 assimilation, provides a mechanism for the utilization of light energy without the consumption of water.

It is conceivable that devices other than closure of stomata are also available, both to higher and to lower plants without stomata, for curtailing CO_2 assimilation when the normal photosynthetic products accumulate in the cell. Under such conditions it would greatly benefit the cell to have a supply of ATP generated at the expense of light energy. This ATP of photochemical origin could then be used to drive the many ATP-dependent reactions, notably protein and fat synthesis (*1*). Another example is the synthesis of glutamine, which provides an important mechanism for the incorporation and transfer of nitrogen in plants, and which was also shown by Elliott (*60*) to depend on ATP in accordance with reaction 5:

$$\text{Glutamate} + NH_3 + ATP \rightarrow \text{glutamine} + ADP + P \quad (5)$$

One is tempted to suggest that cyclic phosphorylation itself may, under certain conditions, be a device for diverting light energy into channels other than CO_2 assimilation. Cyclic photophosphorylation would thus represent a pattern evolved by photosynthetic cells to use light energy for accomplishing cellular work independently of CO_2 assimilation.

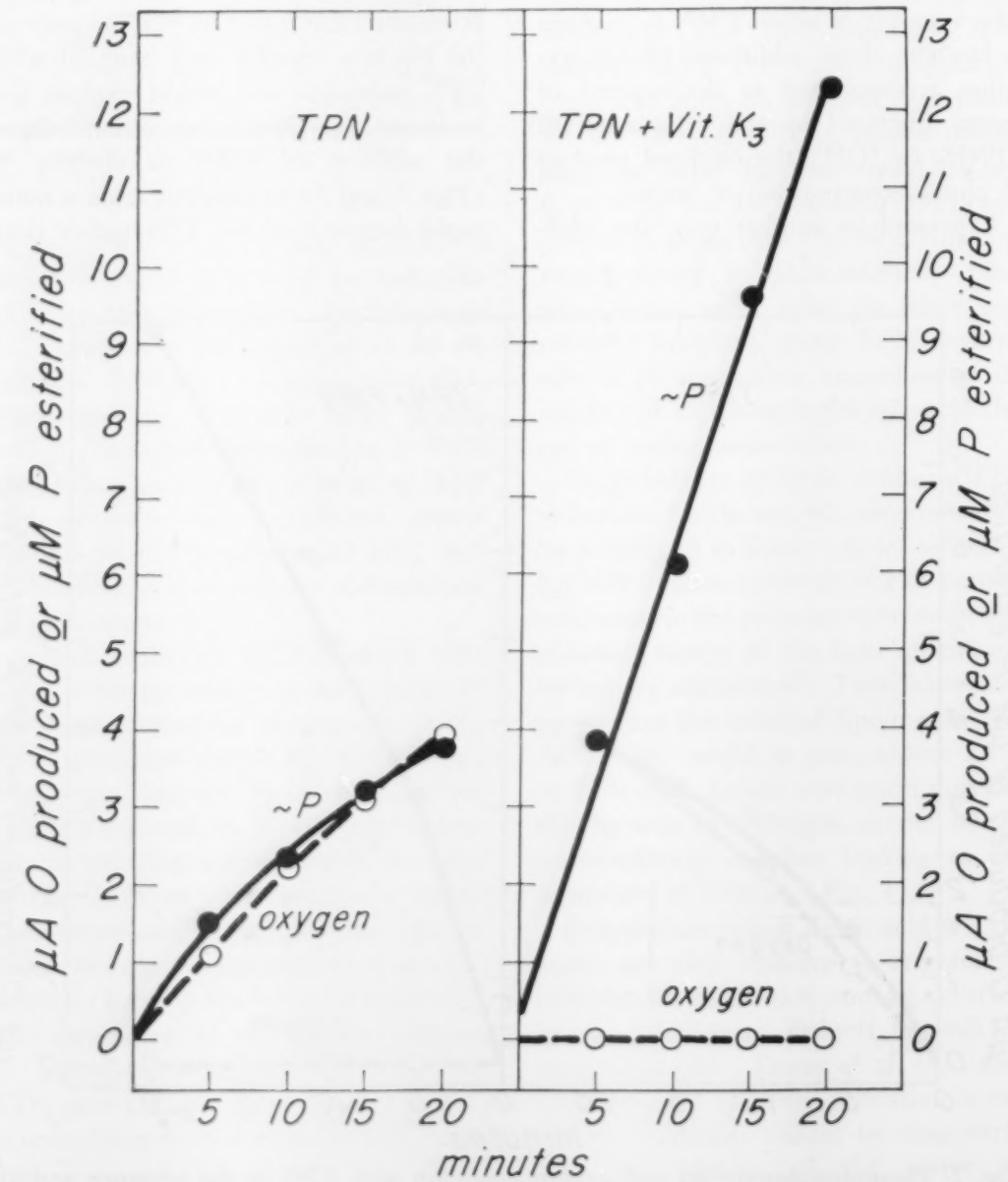

Fig. 8. Photophosphorylation and oxygen evolution with TPN in the presence and absence of vitamin K_3. Experimental conditions were the same as those described in Fig. 7. In the "TPN + vit. K_3" series, 0.2 μmole of vitamin K_3 (menadione) was added.

Cyclic Photophosphorylation and Quantum Efficiency Measurements

If cyclic photophosphorylation is concurrent with CO_2 assimilation, then the portion of light energy which it consumes will not be accompanied either by oxygen evolution or by CO_2 uptake. Quantum efficiency values for the over-all process of photosynthesis, dependent as they usually are on the measurements of these two gases, would therefore be low in proportion to the share of light energy which is diverted to cyclic photophosphorylation. One possible explanation, attractive because of its simplicity, of the high quantum efficiency yield obtained by Warburg *et al.* (*61*) with cells grown in fluctuating light is that they divert little if any of the absorbed light energy from CO_2 assimilation to cyclic photophosphorylation. On the other hand, the seemingly less efficient cells grown under constant illumination may already contain an accumulation of carbohydrates or of other photosynthetic products and would then use a larger share of the absorbed light energy for cyclic photophosphorylation to generate ATP, to be used for protein synthesis and other endergonic processes.

Catalysts of photosynthetic phosphorylation. In previous formulations it was tentatively proposed (*5, 6, 26, 36*) that FMN and vitamin K are members of the same electron transport chain of what is now termed cyclic photophosphorylation. Whatley *et al.* (*62*) have shown, however, that under modified experimental conditions maximal rates of cyclic photophosphorylation are obtained with either FMN or vitamin K as catalysts (Table 1). On the basis of present evidence, vitamin K and FMN are therefore tentatively regarded as participating in alternative pathways for cyclic photophosphorylation. The postulated "FMN pathway" is shown in Fig. 9. The "vitamin K pathway" differs from the "FMN pathway"; for example, it is insensitive to $10^{-3}M$ dinitrophenol. Other differences and similarities between these two postulated pathways are now under investigation. This subject is discussed more fully elsewhere (*63, 64*).

The marked stimulating effect of phenazine methosulfate on photosynthetic phosphorylation is sometimes interpreted as casting doubt on the specificity of vitamin K and flavins as the natural cofactors of photosynthetic phosphorylation (*30*). Analogous effects of phenazine methosulfate as an electron carrier in the succinic and other dehydrogenase systems (*65*) have led to no questions about the specificity of the natural cytochrome system in these reactions. We know of no valid reason at this time for questioning the experimentally demonstrated role of vitamin K (*11*, Table 1) and FMN (*10*) in photosynthetic phosphorylation. Both of these substances are normal constituents of chloroplasts; in fact, Dam has shown that in green leaves vitamin K is concentrated in chloroplasts (see review, *63*). We are therefore inclined to favor Geller's interpretation (*17*) that, in photosynthetic phosphorylation, phenazine methosulfate merely "serves as a fast 'by-pass' or 'short circuit' for electron transport around the site which is rate limiting in the system."

Present evidence suggests that the role of ascorbate may be to protect some essential components of the chloroplasts against inactivation (*39*). We are now inclined to assign to ascorbate a protective action and to consider it to be perhaps a poising agent, rather than a catalyst in the electron transport chain (Fig. 9). Contrary to the report of Wessels (*23*), ascorbate, under our experimental conditions (*64*), markedly increased phosphorylation with either FMN or vitamin K, under anaerobic conditions (Table 1).

The requirements for Mg^{++} and TPN

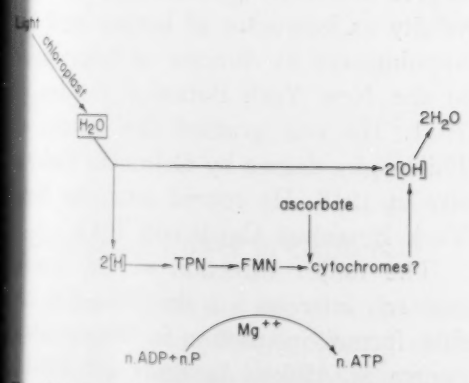

Fig. 9. Diagram representing cyclic photophosphorylation induced by the addition of catalytic amounts of riboflavin phosphate (FMN) to a chloroplast system generating assimilatory power (Figs. 3 and 7). The suppression of oxygen evolution and the increase in phosphorylation (Fig. 7, right) are visualized as resulting from additional phosphorylation steps coupled with the stepwise recombination of the elements of water.

and the possibility that there is a cytochrome requirement in photosynthetic phosphorylation are discussed elsewhere (*63, 64*).

Several soluble enzymes and other factors contained in chloroplasts have now been identified as likely components of photosynthetic phosphorylation: (i) adenylic acid kinase (*24, 28, 39, 66*); (ii) a TPN-reducing factor which has the properties of a protein (*39*) [this factor appears to be the same as that described by San Pietro and Lang (*67*)]; (iii) a diaphorase, specific for $TPNH_2$ as an elecron donor and capable of reducing FMN or vitamin K_3 (*68*).

Phosphorylation and Biochemical Evolution

The presence in green plants of anaerobic mechanisms for generating ATP at the expense of light energy provides another link in the chain of evidence for the basic unity of photosynthetic mechanisms in aerobic green plants and anaerobic photosynthetic bacteria, as proposed by van Niel (*37*). Photosynthetic phosphorylation is also compatible with the premise that the emergence of photosynthetic organisms in the evolutionary scale was accomplished by their acquisition of a pigment system capable of carrying out the photodecomposition of water (*37*).

Our present knowledge of photosynthetic phosphorylation (*69*) suggests that the capacity for harnessing light energy, when first acquired, was probably more closely associated with ATP synthesis than with CO_2 assimilation. This suggestion is based on the close structural association, in both chloroplasts and bacterial chromatophores, of the phosphorylating activity with the chlorophyll pigment system. By contrast, the enzymes responsible for CO_2 assimilation are easily dissociable from the chlorophyll pigment system in the case of chloroplasts (*6, 12, 26*) and apparently not even structurally joined together in the case of bacterial chromatophores (*70*).

The direct use of light energy for the synthesis of ATP by a recombination of the products of the photodecomposition of water would be a significant step forward in supplementing the ATP derived from anaerobic fermentations, which were most probably the oldest energy-releasing processes (see *1*). If it is agreed that, at an early period in the evolution of life forms, organic compounds were abundant and the earth's atmosphere was a reducing one (*71*; also see *1*, review), then new mechanisms for ATP formation were probably more important than CO_2 fixation to the newly emerging organisms. It is assumed that, at first, the mechanism for the reconstitution of water leading to ATP formation was simpler than that now proposed for cyclic photophosphorylation (Fig. 9).

The next step in the evolution of photosynthesis might have been the formation of assimilatory power—that is, the conversion of only a portion of the captured light energy into ATP, the remainder being used to generate a reductant for CO_2 assimilation. Here a recombination of the products of photodecomposition of water had to be prevented, since the "hydrogen" derived from the decomposition of water would be required for the reduction of CO_2. The diversion of the "hydrogen" for CO_2 assimilation would have to be accompanied by a mechanism for disposing of the [OH], the oxidized product of the photodecomposition of water. This mechanism was perhaps, at first, generally dependent on an external hydrogen donor, as it still is today in photosynthetic bacteria. In a later stage of evolution, culminating in the emergence of green plants, this mechanism became an enzyme system for the liberation of molecular oxygen (*37*).

Photosynthetic phosphorylation by chlorophyll-containing particles, being independent of molecular oxygen, could occur before oxidative phosphorylation by mitochondria, which requires molecular oxygen. The only known source for molecular oxygen on earth is photosynthesis by green plants (*37, 71*). This evolutionary sequence provides another argument against the dependence of photosynthesis on ATP generated by a mitochondrial mechanism. It is an in-

Table 1. Effect of riboflavin phosphate (FMN), vitamin K_5 (2-methyl-4-amino-1-naphthol hydrochloride), and ascorbate on photosynthetic phosphorylation under anaerobic conditions.

Treatment	P esterified (μmole)	
	FMN system	Vitamin K_5 system
Complete	7.0	5.5
FMN or vitamin K_5 omitted	0.9	0.9
Chloroplasts omitted	0.2	0.2
Light omitted	0.2	0.2
Complete	6.2	6.8
Ascorbate omitted	0.9	3.8

teresting aspect of biochemical evolution that green plants, after evolving a mechanism independent of molecular oxygen for generating ATP in light, have also shared with nongreen organisms the emergence of an oxygen-dependent generation of ATP by oxidative phosphorylation.

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Arlow B. Stout, Geneticist and Plant Breeder

Arlow Burdette Stout was born at Jackson Centre, Ohio, on 10 March 1876, and died at the age of 81 at his home in Pleasantville, New York, on 12 October 1957.

His youth was spent in a rural community at Albion, Wisconsin, where most of the surrounding land was still uncultivated and offered intimate contact with nature to an eager boy whenever duties on the farm permitted. His education came the hard way, as it did for many of his contemporaries. Beginning in a one-room country school he continued his education at a local academy (Albion Academy), at Melton College, and at the State Normal School at Whitewater, Wisconsin, with frequent interruptions for longer or shorter periods, as required by the need to earn money, usually by teaching. In the autumn of 1908 he entered the University of Wisconsin, from which he received the Bachelor of Arts degree in 1909. He remained at the university as instructor of botany until his appointment as director of laboratories at the New York Botanical Garden in 1911. He was granted the Doctor of Philosophy degree by Columbia University in 1913. He retired from the New York Botanical Garden in 1947.

The major direction of Dr. Stout's research interests was determined by his first formal instruction in botany. In a course at Albion Academy in 1895–96 he used Asa Gray's *How Plants Grow* as a text, and he was especially intrigued with the description of the process of seed formation. However, he was most surprised and perplexed to note, the following summer, that two plants in his family's garden produced perfect flowers but did not fruit. These plants were a cluster of the familiar day lily (*Hem-*

erocallis fulva) and a colony of the tiger lily (*Lilium tigrinum*). His curiosity, aroused by this observation, persisted through the years and led him to undertake extensive studies on sterility and fertility of flowering plants, including the day lily.

Dr. Stout's early major interests included ornithology and archeology, and his decision to pursue botany as a career was not made until he graduated from the University of Wisconsin. This decision was greatly influenced by R. A. Harper, then professor of botany at Wisconsin, and by Zelda Judd Howe, who became Mrs. Stout in 1909.

The 36 years he spent at the New York Botanical Garden were mainly devoted to research on plant breeding, cytology, and genetics, with particular reference to the problems of sterility and fertility of seed plants. He investigated various aspects of the breeding of apples, avocados, cherries, chicory, Chinese cabbage, coleus, day lilies, dates, grapes, lilies, lily-of-the-valley, lobelia, moss pink, narcissus, Norway maple, pears, petunias, poplars, white potatoes, and sweet potatoes.

An investigation of the irregular fruiting of avocado in California and in Florida resulted in the discovery of an extraordinary mechanism of cross-pollination. For seven years, beginning in 1924, he planned, directed, and (with E. J. Shreiner) participated in an extensive program of hybridization of the poplar tree, producing some hybrids with notable hybrid vigor. Studies of the sterilities of the white potato were carried out in cooperation with the U.S. Bureau of Plant Industry; some of the work was done at Presque Isle, Maine. In cooperation with the New York State Agricultural Experiment Station at Geneva, Dr. Stout began an investigation of seedless grapes, in 1919, which included studies of the nature of seedlessness and its heredity and breeding for hardy seedless grapes. These studies were continued until his retirement and resulted in the production of numerous seedlings with seedless or near-seedless berries, some of which evidenced considerable hardiness and promise for commercial use. His investigations of the day lily (*Hemerocallis*), begun in 1911 during his first year at the New York Botanical Garden, were continued throughout his life. They included studies of the taxonomy of the genus, interspecific hybrids, comparative cytology of species and hybrids, self- and cross-incompatibilities, and the selection of seedlings for garden culture. His investigations, besides contributing to knowledge of the phenomena of sterilities and the complexities of their genetics, transformed the day lily from a minor garden plant to one of the most varied and reliable of perennials. The results of his work were published in some three hundred and fifty papers.

After his retirement, he served as a consultant to seed growers, continued his breeding of *Hemerocallis*, published a monograph on *Petunia*, and engaged in a comprehensive study of *Rubus*.

All who knew him were aware of his dedication to science. Hours meant nothing to him. He asked only for the opportunity to devote his energies to those important unsolved problems which had aroused his curiosity. While deeply concerned with the theoretical and basic aspects of cytology and genetics, he appreciated the applied aspects of plant breeding and, like Pasteur, never hesitated to investigate a problem of practical importance, carrying the research as deeply into the fundamentals as time and facilities permitted.

Dr. Stout participated in the activities of the community in which he lived, and his sterling qualities, as a man as well as a scientist, were appreciated by his friends and neighbors, as well as by his colleagues.

He is survived by his wife; a daughter, Elizabeth B. Rausch of Orlando, Florida; a brother, C. D. Stout; and a granddaughter.

WILLIAM J. ROBBINS
New York Botanical Garden,
Bronx Park, New York

News of Science

Geothermal Power in California

Just a few miles north of Santa Rosa, Calif., at Big Geysers, a concern calling itself the Thermal Power Company is engaged in the somewhat exotic business of drilling bores in the rock to tap subterranean steam with a view to harnessing this natural energy for the production of electrical power. This concept of the economic development of geothermal energy is relatively new, for natural steam emanating from the earth in the form of geysers and fumeroles has been regarded traditionally as a scientific curiosity, and regions exhibiting such phenomena have been set aside as parks and tourist attractions. But in the last few years, a number of nations in many parts of the world have been re-evaluating their thermal areas as something more than mere spectacular scenery. For in our modern mechanized society with its great dependence on fossil fuels as energy sources, the doubling and redoubling of power requirements in the postwar years has placed a heavy strain on these patently exhaustible resources. As a result, energy sources which are essentially inexhaustible, such as falling water, nuclear fission, and geothermal steam, are receiving increased attention.

The theory supporting contentions that subterranean steam is a virtually inexhaustible resource is based on the conversion of both meteoric water and magmatic water to steam. Meteoric water, or ground water, contacting hot rocks near the surface is commonly held responsible for geyser phenomena and is certainly accountable for the occurrence of large quantities of steam; but it is magmatic water, reckoned at about 10 percent of the superheated earth's core and released upon cooling and crystallization of magma into igneous rock, that makes up the bulk of the steam reserve. Taking both of these sources into consideration, Italian scientists at Lardarello, Tuscany, where the pioneer project of this type has produced power for many years, have estimated that at the present rate of energy withdrawal from the proven geothermal area, reserves are sufficient for another 11,000 years.

However, despite the success of the Italian development and its expansion following the war, little attention had

been paid to geothermal development until very recently, when a major project was begun in New Zealand [*Science* **126**, 440 (6 Sept. 1957)]. Taking advantage of an extremely favorable set of natural and economic circumstances on the North Island, the New Zealand government in 1950 launched a widely publicized program to utilize geothermal steam to produce electric power on a large scale. The apparent success in New Zealand (the schedule calls for initial power deliveries this year) triggered a rash of exploration and development schemes in a number of other widely scattered locations around the world. In Mexico, Iceland, El Salvador, Chile, Fiji, the British Windward Island of St. Lucia, and at the aforementioned Big Geysers, drilling programs are in the planning stages or already underway.

The "hot land" at Big Geysers involves 3200 acres extending for about 5 miles along the north side of a fault-line canyon. The release of pressure on the magma below at the time of faulting undoubtedly accounts for the presence of hot rocks relatively near the surface. Proving the presence of steam at a very shallow depth are five active fumerole areas and eight 500- to 600-foot wells drilled with primitive equipment in 1923–25 by a group of local men (among them, the late Luther Burbank) which are today still issuing steam with undiminished force. In 1955, leasing the land from the owners, Geyser Development Company, the Magma Power Company of Nevada drilled a test hole to a depth of 603 feet and also encountered steam. But financial difficulties retarded further exploration. In late 1956 Magma entered into a contract with the newly formed Thermal Power Company under which Thermal agreed to invest a minimum of $230,000 in test drilling, thereby acquiring a one-half interest in the lease. As it stands at the moment, Thermal is about to put down its first deep well, utilizing modern equipment of the type that has plumbed depths of from 1000 to 3000 feet in Italy and New Zealand. To supervise the operation, the company has retained as its consulting engineer Earl P. English, formerly vice president of Bechtel Corporation and consultant for Bechtel in recent drilling of New Zealand wells.

The Big Geysers project is still in the early, speculative stage and the aim is merely to test the energy potential of the property by drilling at many different locations and varying depths. Only after the results are in on this exploration and testing can plans be forthcoming for the economic utilization of the steam. Nonetheless, close observers exhibit a cautious optimism, pointing out that the eight old shallow wells, together with Magma No. 1, are blowing an estimated 6000 kilowatts of energy into the air; to duplicate this in a modern power plant would require the burning of 240 barrels of fuel oil or 1,444,000 cubic feet of gas per day. Temperatures at the 600-foot level have been determined at 600 degrees, and if the heat gradient continues to rise in proportion to depth, 1000- to 1500-foot bores might be expected to have very high temperatures and yield at least the equivalent of 4000 kilowatts per well (New Zealand wells have averaged 6000 kilowatts). So far Big Geysers steam, even for existent shallow bores, has proved to be dry, in contrast to the wet steam found in other areas; wetness constitutes a turbine corrosion hazard. Further, engineering reports on the region state that wells can be drilled as close together as 150 feet without reducing the production of their neighbors, and that the ultimate potential of the property could easily exceed 30 wells, or 100,000 kilowatts, should a substantial portion of the property prove productive.

If such results can be achieved, geothermal steam can compete very favorably in power production. For despite the large hydroelectric projects, both planned and under construction, California is very likely to continue chronically power-short as her population and industrialization maintain their phenomenal rate of increase. Geothermal steam shares with all other energy sources generating electric power the 300- to 400-mile transmission limit due to line loss, but it has a double advantage over hydrogeneration in not being subject to the vagaries of seasonal stream flow or the conflicting water requirements of irrigation vs. power development. Similarly, the sharp increases in fuel prices in the past few years, plus the need for boilers, which constitute 30 to 40 percent of overall power-plant costs, give geothermal steam a real advantage over standard thermal plants.

MICHAEL P. MCINTYRE
Department of Geography,
San Jose State College

Physical Review Letters

The *Physical Review* has announced that, beginning with the 1 July issue, "Letters to the Editor" will no longer appear in the *Review* but will be published in a supplemental semimonthly journal tentatively called *Physical Review Letters*. Because offset printing will be used, it will be possible to publish letters within 2 to 3 weeks after receipt instead of the present 6 to 10 weeks. The new *Physical Review Letters* will also contain abstracts of *Physical Review* articles that are scheduled for future publication.

Initially *Physical Review Letters* will be sent to all subscribers of the *Physical Review*. However, beginning in January 1959, a subscription price of $5 for members of the American Physical Society and $10 for nonmembers will be charged. At that date the publication charge in *Physical Review Letters* will be set at $30 instead of the present $25 per page.

A fast-publishing journal such as *Physical Review Letters* may become very popular with authors and could soon grow beyond reasonable bounds. Therefore the same strict standards that are now in operation for "Letters to the Editor" will be maintained for the new publication. It is expected that, on the average, only about 15 letters will be acceptable for each issue. "Letters" will be accepted only if they contain important new discoveries or deal with topics of high current interest in rapidly changing fields of research. All other contributions, no matter how short they may be, should be submitted for publication as articles in the *Physical Review*. Subscriptions for the new journal will be handled by the American Institute of Physics, 335 E. 45th St., New York 17, N.Y.

Suggestions on Undergraduate Biology Courses

The Committee on Educational Policies of the Division of Biology and Agriculture, National Academy of Sciences–National Research Council, has recently published reports on new approaches to the teaching of systematic botany and parasitism. The studies were prepared (with the aid of a National Science Foundation grant) to test an idea for meeting the recurrent problem of keeping teaching abreast of scientific advances [*Science* **125**, 809 (26 Apr. 1957)]. One method, the committee suggested, is to invite an *ad hoc* panel of competent individuals, each expert in a different branch of a given subject, to redefine course objectives and content. This tactic merely adapts the research symposium to consideration of teaching problems, with the hope of encouraging continuing experimentation and re-evaluation in teaching by individual instructors.

Members of each panel found, despite wide initial differences of view, that they could develop interesting new syntheses of content, with suggestions for adaptations to different teaching situations. The botanical report (published in the *Plant Science Bulletin*, January 1958) takes a broad view of systematic biology that should also interest zoologists. The parasitism report (published in the *Journal of Parasitology*, February 1958) looks toward a basic course on the biology of parasitism. More generally, the committee believes that the reports illustrate the

value of the approach and recommends that groups concerned with any biological areas consider the organization of similar *ad hoc* panels to help stimulate re-examination of undergraduate courses. A limited number of reprints of the two reports are available from the committee, 2101 Constitution Ave., NW, Washington 25, D.C.

Winds in the Upper Atmosphere

Using rockets which release confetti-like aluminum chaff more than 50 miles above the earth, Army scientists are plotting winds in the upper atmosphere. With this new method, developed at the U.S. Army Signal Engineering Laboratories at Fort Monmouth, N.J., a cloud of chaff is released and tracked by radar to produce a fast and accurate wind profile. The chaff has been swept along at some 200 miles an hour by the winds. Continuous measurements have been made from the maximum altitude of 283,000 (about 54 miles) down to levels of less than 100,000 feet.

The results of recent tests at White Sands, N.M., and Patrick Air Force Base, Fla., show that the metallic chaff method can provide an unbroken map of wind speed and direction—the first time this has been possible at such altitudes. Findings on winds within the test zones show that they are generally easterly and have about the same speed as the westerly "jet streams" found at altitudes of 30,000 to 40,000 feet. Hans J. aufm Kampe and Dudley E. Cline of the Army Signal Corps, one a physicist and the other an engineer, have been active in the development of the new wind-measuring technique.

Proposed Legislation

Of the many bills introduced in Congress, some have a special relevance to science and education. A list of such bills recently introduced follows:

HR 11261. Establish a self-liquidating scholarship loan fund to enable highly qualified high-school graduates in financial need to receive a college education. Keating (R-N.Y.). House Education and Labor.

HR 11329. Amend title IV of Housing Act of 1950 to authorize loans under college housing loan program for construction of science buildings and libraries at educational institutions. O'Brien (D-N.Y.). House Banking and Currency.

HR 11392. Create a Department of Science and prescribe its functions and establish a U.S. Science Academy within such department. Christopher (D-Mo.). House Government Operations.

HR 11271. Provide for establishment of Bureau of Older Persons within Department of Health, Education, and Welfare; authorize federal grants to assist in development and operation of studies and projects to help older persons. Ullman (D-Ore.). House Education and Labor.

HR 11414. Amend section 314(c) of Public Health Service Act, to authorize Surgeon General to make certain grants-in-aid for support of public or nonprofit educational institutions which provide training and services in fields of public health and in administration of state and local public-health programs. Rhodes (D-Pa.). House Interstate and Foreign Commerce.

HR 11363. Amend Communications Act of 1934 to prohibit subliminal projection by television stations. Hosmer (R-Calif.). House Interstate and Foreign Commerce.

S 3537. Encourage discovery, development, and production of manganese-bearing areas in U.S., its territories and possessions. Martin (R-Iowa). Senate Interior and Insular Affairs.

S 3539. Amend part VI of subtitle C, title 10, U.S.C. to authorize Secretary of Navy to take possession of naval oil shale reserves. Allott (R-Colo.). Senate Armed Services.

S 3606. Provide financial assistance to the states for educational purposes by returning to the states a portion of federal income taxes collected therein. Proxmire (D–Wis.). Senate Labor and Public Welfare.

HR 11776. Provide for national security through programs designed to increase the number of students in mathematics, science, engineering, and modern foreign languages in institutions of higher education. Provide additional facilities for teaching of such subjects. Assist teachers to increase their knowledge. Byrd (D–W.Va.). House Education and Labor.

HR 11785. Strengthen national defense, advance the cause of peace, and assure the intellectual pre-eminence of the United States, especially in science and technology, through programs designed to stimulate the development and increase the number of students in science, engineering, mathematics, modern foreign languages, and other disciplines. Provide additional facilities for the teaching thereof. Promote the development of technical skills essential to national defense. Assist teachers to increase their knowledge and improve their effectiveness. Gray (D–Ill.). House Education and Labor.

HR 11830. Provide for a federal program of loans to encourage and assist able and needy students to continue their education beyond the high-school level. Lane (D–Mass.). House Education and Labor.

HR 11833. Encourage expansion of teaching and research in education of mentally retarded children through grants to institutions of higher learning and to state educational agencies. May (R–Conn.). House Education and Labor.

HR 11854. Provide a federal grant program to assist the states and localities in the construction of schools. Engle (D–Calif.). House Education and Labor.

S 3582. Authorize the establishment of a Youth Conservation Corps to provide healthful outdoor training and employment for young men and to advance the conservation, development, and management of national resources of timber, soil and range, and of recreational areas. Humphrey (D–Minn.), Murray (D–Mont.), Neuberger (D–Ore.), Proxmire (D–Wis.), Jackson (D–Wash.). Senate Labor and Public Welfare.

S 3588. Amend title VI of the Public Health Service Act, as amended, in order to make certain clinics in rural areas eligible for federal aid to diagnostic or treatment centers. Payne (R–Me.), Flanders (R–Vt.). Senate Labor and Public Welfare.

S 3595. Amend section 406 of the Federal Food, Drug, and Cosmetic Act in order to provide that maximum concentrations for certain color additives used in coloring oranges be prescribed by regulation. Holland (D–Fla.). Senate Labor and Public Welfare.

HR 11835. Provide for holding a White House Conference on Aging to be called by the President of the United States before 31 December 1958, to be planned and conducted by the special staff on aging of the United States Department of Health, Education, and Welfare with the assistance and cooperation of other agencies of that department and of other departments and agencies represented on the Federal Council on Aging. Assist several states in conducting similar conferences on aging prior to the White House Conference on Aging. Rodino (D–N.J.). House Education and Labor.

S 3593. Amend the Atomic Energy Community Act of 1955 in order to authorize the Atomic Energy Commisison to dispose of certain property for college purposes. Gore (D–Tenn.), Kefauver (D–Tenn.). Joint Atomic Energy.

S 3604. Amend the act of 3 March 1915, which established the National Advisory Committee for Aeronautics, and establish the National Astronautics Agency. Case (R–S.D.). Special Committee on Space and Astronautics.

HR 11860. Amend the act of 3 March 1915, as amended, to increase the scope of the activities of the National Advisory Committee for Aeronautics (renamed in this act the National Advisory Committee for Aeronautics and Astronautics),

to establish in the Congress a Joint Committee on Astronautics, and for other purposes. Fulton (R–Pa.). Select Committee on Astronautics and Space Exploration.

HR 11805. Promote the national defense by authorizing the construction of aeronautical research facilities by the National Advisory Committee for Aeronautics necessary to the effective prosecution of aeronautical research. Kitchin (D–N.C.). House Armed Services.

HR 520. Provide for printing as a House document the statement entitled "Introduction to Outer Space." Arends (R–Ill.). House Administration.

HR 11838. Supplement the act of 3 July 1952 by providing for construction of a full-scale demonstration plant in Ventura County, Santa Barbara County, San Luis Obispo County, or Monterey County, Calif., for the production of fresh water from salt water. Teague (R–Calif.). House Interior and Insular Affairs.

News Briefs

The Soviet Government news agency Tass announced on 15 April that Sputnik II, which contained the carcass of a dog, had disintegrated that morning over the Lesser Antilles, Brazil, and the Atlantic Ocean. During the satellite's 5½ months in orbit (it was launched 3 November 1957) it had completed about 2370 trips around the world. It is said to have traveled about 62 million miles.

* * *

Thirty-six governments have now submitted a total of 1925 titles of scientific papers for presentation at the Second International Conference on the Peaceful Uses of Atomic Energy, to be held in Geneva, 1–13 September, by the United Nations. Approximately 900 abstracts have been proposed for presentation by the United States.

* * *

The inaugural meeting of the Indian Society for Plant Physiology was held on 24 January at the University of Allahbad, when the constitution of the society was adopted and officers were elected. The president is P. Parija, vice-chancellor of Utkal University, Cuttack. Kenneth V. Thimann, professor of botany at Harvard University, was elected an honorary member.

* * *

A special summer laboratory course in the techniques and applications of the electron microscope will be offered to senior biologists and medical research workers at Cornell University from 16 June through 3 July. The course, which is under the direction of Benjamin M. Siegel, is being sponsored by a grant from the National Science Foundation. Well-known guest lecturers will participate. Requests for information should be addressed to Siegel at Rockefeller Hall, Cornell University, Ithaca, N.Y.

* * *

The Atomic Energy Commission has released information on 15 past nuclear explosions, revealing that at least seven explosions took place in the Pacific in 1954 and 1956 that never were announced. A list of seismological data on the 15 tests is being distributed by the Division of Earth Sciences, National Academy of Sciences–National Research Council, Washington 25, D.C.

* * *

The Experimental Boiling Water Reactor at Argonne National Laboratory of the Atomic Energy Commission, Lemont, Ill., was operated recently at a power level of 62,000 kilowatts of heat. This operating level is more than triple the original design operating level of 20,000 kilowatts. In December 1957 the EBWR was operated in experiments at 50,000 kilowatts of heat. The recent increase in the thermal output of the EBWR is a result of months of experimentation. Such an increase would increase the amount and reduce the unit cost of electricity produced by the plant if increased generating capacity were installed.

* * *

A research team at the University of California's Radiation Laboratory has photographed the annihilation of an antineutron. This is considered the newest evidence of the great efficiency with which matter and antimatter destroy each other when they touch. Emilio Segrè announced the achievement on 11 April when he was lecturing at New York University.

* * *

In only 4 years, world population grew by about 172 million. That equals the total population of the United States today. World population rose from 2.519 billion in 1951 to 2.691 billion in 1955, an increase of 118,000 persons each day.

The average annual rate of natural increase (excess of births over deaths) for the period was about 1.7 percent, the most rapid rate of growth in world history. These are a few of many highlights stressed in a recent United Nations report.

* * *

State laws concerning private schools are reported in a new study, the first of its kind, by the U.S. Office of Education. A 152-page publication, *The State and Nonpublic Schools,* describes the legal framework within which these educational institutions operate and reports on the responsibilities of state departments of education in connection with them.

* * *

Despite an increase in admissions, the population of this country's mental hospitals continued to decline in 1957, according to a survey released recently by the American Psychiatric Association and the National Association for Mental Health. This is the second year of downtrend in mental hospital rolls after a 25-year climb.

* * *

The astronomy department of the University of California is organizing a conference for college teachers of astronomy between 7 July and 1 August. The conference will be sponsored jointly by the university and the National Science Foundation. The participants (limited to about 20 persons) will receive travel and living-expense allowances. Persons wishing to take part in the conference, which will be directed by Cecelia P. Gaposchkin of Harvard University, should write as soon as possible to the astronomy department of the University of California, Berkeley.

Scientists in the News

A memorial service honoring RUDOLPH MATAS, and the seventh presentation of the Rudolph Matas Award in vascular surgery, will be held on 9 May at the Tulane University School of Medicine. Dr. Matas, who died in September 1957 at the age of 97 years, served Tulane's department of surgery all of his adult life, becoming professor and head of the department in 1894.

The Matas award will be presented to JOHN H. GIBBON, JR., Samuel D. Gross professor of surgery and head of the department at Jefferson Medical College. He is being honored for his pioneering efforts in the field of extracorporeal circulation, which resulted in the development of a heart-lung apparatus.

HAROLD S. BLACK, research engineer for Bell Telephone Laboratories, Inc., is to receive the 1957 Lamme Gold Medal of the American Institute of Electrical Engineers "For his many outstanding contributions to telecommunications and allied electronic arts, especially the negative feedback amplifier and the successful development and application of the negative feedback amplification principle." The medal will be presented to Black on 23 June during the summer general meeting of AIEE in Buffalo, N.Y.

RUSSELL GIBSON has left the United States to take up a year's assignment in Pakistan, where he will advise on the search for atomic raw materials under the United Nations Technical Assistance Administration. Among Gibson's duties will be the undertaking of a preliminary survey. He will advise Pakistan's Atomic Energy Commission on a comprehensive program for an atomic

raw materials ground survey in both East and West Pakistan. His recommendations will also cover the training of local personnel, both to carry out the ground survey and to implement the survey program.

Gibson has had wide experience in geological surveys in the United States, Mexico, Argentina, China, Bolivia, Iran, India, Chile, and Costa Rica. From 1927 to 1954 he served as instructor, assistant professor, and associate professor in the geology department of Harvard University, specializing in the economic aspects of geology.

JOHN HORN, consultant, Technical Data Consulting Service, General Electric Company, has retired from the company after 39 years of service. He expects to devote his time to the investigation and reporting of technological trends in Europe for the benefit of American industry.

Horn joined General Electric in Schenectady, N.Y., in November 1919 to inaugurate the General Electric Technical Translation Service. In 1924 he turned to collecting, organizing, and disseminating technical information throughout the company, and in that connection became the technical information liaison agent on information to and from affiliated foreign companies.

He is the originator of the General Electric Technical Information System, which disseminates technical information throughout the company. For 15 years he has been the editor of the firm's activities bulletin for communicating information between laboratories. He has participated in the education of design draftsmen, the establishment and conduct of the General Electric Technician Program, and the assignment of apprentices within engineering. He is the author of several papers on material conservation, technical report writing, documentation, and allied subjects.

Horn, who was born in Oslo, Norway, was educated in the Norwegian school system, and graduated from the Technical Institute of Horten, Norway, in 1912.

RICHARD G. FOLSOM, former director of the Engineering Research Institute and professor of mechanical engineering at the University of Michigan, assumed his new post as president of Rensselaer Polytechnic Institute on 1 March. He succeeds LIVINGSTON W. HOUSTON, who retired after 14 years as president.

At its meeting in March, the chairman of the National Science Board announced the appointment of a Committee on Social Sciences consisting of the following: Father THEODORE M. HESBURGH, president, University of Notre Dame, chairman; DONALD H. McLAUGHLIN, president, Homestake Mining Company; DOUGLAS M. WHITAKER, vice-president for administration, Rockefeller Institute for Medical Research; and FREDERICK A. MIDDLEBUSH, president emeritus and director of the Development Fund, University of Missouri.

PAUL A. SIPLE, leader of the first group of men ever to winter at the South Pole, has received the National Geographic Society's Hubbard Medal, one of geography's highest awards. The gold medal bears the citation: "To Paul A. Siple, whose bold Antarctic explorations and researches spanning 30 years have broadened the horizons of geographic knowledge." Siple first went to the Antarctic as a 19-year old Eagle Scout with Richard E. Byrd. He now serves as a civilian polar expert in the Army's Office of Research and Development in Washington.

JOSEPH E. MAYER, Carl Eisendrath professor in the department of chemistry and the Enrico Fermi Institute for Nuclear Research of the University of Chicago, has been awarded the Gilbert Newton Lewis Medal of the California Section of the American Chemical Society. He is being honored for his "outstanding contributions in statistical thermodynamics, pioneering work in the statistical mechanics of fluids and solutions, successful theoretical and experimental investigations of critical phenomena, and illuminating contribution to the theory of electrolytes." The medal will be presented to Mayer in Berkeley, Calif., on 12 May, when he will deliver an address on "Theory of Time Changes (the Statistical Mechanics of Time Dependent Systems)."

PAUL D. V. MANNING has been named professor of chemical engineering at the California Institute of Technology, effective 1 July. He will retire on 30 June from his position as senior technical vice president, International Minerals & Chemical Corporation, Chicago, after 17 years of service. He joined International in 1941 as director of research and 2 years later was made a vice president.

A. T. GREEN, director, and Mr. DINSDALE, assistant director, of the British Ceramic Research Association, Stoke-on-Trent, England, will be in the United States until 4 June. They will visit San Francisco, Los Angeles, Pittsburgh, Columbus, Detroit, Chicago, Boston, Baltimore, and Washington.

J. RUSSELL BRIGHT, associate dean and former chairman of the department of chemistry at Wayne State University, has been appointed chairman of the state of Michigan's new 16-member Science Advisory Board.

LEO C. YOUNG of the Naval Research Laboratory received the Distinguished Civilian Service Award, the Navy's highest civilian award, on 28 March. Young, who has more than 40 years of Navy service, was honored for his contributions in the field of radio communication, radar, electronics identification, and radio control.

The 1958 Jacob F. Schoellkopf Medal of the Western New York Section of the American Chemical Society has been awarded to ROBERT B. MacMULLIN, senior partner of R. B. MacMullin Associates, consulting engineers of Niagara Falls, N.Y., "for his original contributions to the science of chemical engineering, and for his achievements at home and abroad, as a consulting engineer, particularly in the field of industrial electrolytic processes." The medal will be presented on 20 May at a dinner meeting at the Hotel Niagara, Niagara Falls.

JAMES M. GAVIN has been elected vice president and a director of Arthur D. Little, Inc., Cambridge, Mass. Prior to his retirement at Fort Bragg, N.C., on 31 March, Gen. Gavin was Army chief of research and development. He will assume his new duties as an adminstrative officer on 1 June at Acorn Park, Little's research center in West Cambridge, Mass.

SERGE A. KORFF, professor of physics at New York University College of Engineering, has been named Professor Honorario en Radiacion Cosmica of the Chacaltaya Laboratory of Cosmic Physics, which is part of the Universidad Mayor de San Andres of La Paz, Bolivia. Korff received the title in recognition of his work in cosmic radiation and his cooperation with the Chacaltaya Laboratory.

CLAIR F. FELLOWS, director of the Detroit Edison Company's engineering laboratory and research department, retired on 1 April after more than 38 years of service. Fellows is a chemical engineering graduate of Purdue University. He joined Edison in 1919 as a chemist in the company's research laboratory—the first full-scale research facility recorded in the electric power industry. He was named head of the chemical division in 1925 and was appointed director of the department in 1952.

During his Edison career he undertook some of the first industrial studies to determine the behavior of steel at high temperatures and pressures. He also won recognition as a pioneer in the study of water treatment and corrosion problems

related to power-plant operation. Fellows, who is past-president of the American Society for Testing Materials, is the author of numerous articles on problems involving the application of chemical principles in the electric power industry.

LOWELL O. RANDALL, director of pharmacology for Hoffmann–La Roche, Inc., Nutley, N.J., has been awarded an honorary doctor of science degree by Mount Union College, Alliance, Ohio.

WILLIAM G. VAN DER KLOOT, associate professor of zoology at Cornell University, will become professor and chairman of the department of pharmacology at New York University College of Medicine at the close of the academic year.

The Geophysics Research Directorate, Air Force Cambridge Research Center, Bedford, Mass., has announced the selection of RITA C. SAGALYN as Guenter Loeser Memorial Lecturer for 1958. Sagalyn will speak on "Recent Investigations of Electrical Phenomena in the Atmosphere" at 2 P.M. on 4 June, in the Charter Room of the New England Mutual Building, Boston, Mass.

H. J. C. MACMILLAN, formerly chief of laboratories at Lemuel Shattuck Hospital, Department of Public Health, Commonwealth of Massachusetts, and instructor in gynecology at Boston University, has joined Bio-Research Institute, Incorporated, and Bio-Research Consultants, Cambridge, Mass., as chief pathologist and cytologist.

ROBERT M. FARRIER has been appointed assistant director of the National Institutes of Health Clinical Center, Bethesda, Md. He replaces STUART M. SESSOMS, now assistant director of the National Cancer Institute. Farrier has been a commissioned officer in the Public Health Service since 1948. Since 1954 he has been on special assignments for the headquarters office of the Bureau of Medical Services.

H. K. NEWBURN, since 1953 president of the Educational Television and Radio Center, Ann Arbor, Mich., has announced that he will leave this position in September. The decision corresponds with his expressed intent to return to university administration when he was named the first full-time head of the Ann Arbor organization.

The University of Michigan has announced the following appointments: GEORGE E. HAY, who has been acting chairman of the department of mathematics since September and a member of the faculty since 1940, has been made chairman of the department, effective immediately and until 30 June, 1962; PAUL M. FITTS of Ohio State University has been appointed as professor of psychology, effective in September; GORDON J. VAN WYLEN, a professor of engineering at Michigan since 1951, has been appointed chairman of the department of mechanical engineering, effective in July; PHILLIP C. CLEMMOW, who will be on sabbatical leave as university lecturer at Cambridge University, Cambridge, England, has been named visiting professor of electrical engineering for 1958–59; PAUL F. ZWEIFEL, consulting physicist with the General Electric Company's Knoll's Atomic Power Laboratory, has been appointed associate professor of nuclear engineering in the department of electrical engineering for a period of 2 years, effective 1958–59; and GIUSEPPE PARRAVANA, associate professor of chemical engineering at the University of Notre Dame, has been appointed associate professor of chemical engineering for a 2-year period, September 1958 to June 1960.

Four physicians whose work has contributed to research on drug addiction were cited for their accomplishments by the Secretary of Health, Education, and Welfare at a recent dinner held in their honor at the Officers Club of the Navy Medical Center in Bethesda, Md. Letters of commendation were presented to two retired assistant surgeons general, LAWRENCE KOLB of Washington, D.C., and WALTER L. TREADWAY of Santa Barbara, Calif.; to NATHAN B. EDDY, chief of the section on analgesics of the Chemistry Laboratory, National Institute of Arthritis and Metabolic Diseases; and to the widow of the late LYNDON F. SMALL, former chief of the Laboratory of Chemistry of the National Institute of Arthritis and Metabolic Diseases.

ALFRED B. FOCKE, former director of the University of California's Marine Physical Laboratory, has been named chief scientist at the U.S. Naval Air Missile Test Center, Point Mugu, Calif. He is a specialist in underwater sound, radar, and radio air acoustics.

DANIEL M. SHAPIRO, formerly of the Columbia–Presbyterian Medical Center in New York, has been appointed associate professor of surgery in the University of Miami School of Medicine. He is in charge of the cancer research program of the department of surgery, to which he has brought a team of trained technicians and a colony of 4000 inbred mice.

HORACE H. HOWE, nuclear physicist, has joined the U.S. Naval Radiological Defense Laboratory, San Francisco, Calif., as head of the accelerator branch, Nucleonics Division. Howe was formerly on the teaching staff of Reed College, and of the University of California, Los Angeles.

Recent Deaths

CHENG TAN CHOW, Johore Bahru, Malaya; 26; for 2 years research associate in the department of biochemistry at the University of Chicago, since January instructor at the University of Malaya; 2 Mar.

JOHN W. CRONIN, Washington, D.C.; 52; Assistant Surgeon General and chief of the Bureau of Medical Services of the U.S. Public Health Service; 2 Mar.

THOMAS S. CUSACK, Brooklyn, N.Y.; 74; psychiatrist and neurologist for more than 40 years; testified as an expert witness at many famous criminal trials; 14 Apr.

ELSE FRENKEL-BRUNSWIK, Berkeley, Calif.; 49; lecturer in psychology at the University of California; associate research psychologist, Institute of Child Welfare; and research associate, Institute of Industrial Relations; 31 Mar.

FRITZ FRIEDRICHS, Wertheim, Germany; 72; engineer with the Normschliff Glasgeräte GmbH., Wertheim; 1 Mar.

FRANK KINGRON–WARD, London, England; 72; botanist who made more than 20 expeditions to China, Tibet, Burma, and India; brought some 300 varieties of oriental plants and shrubs to Europe; 8 Apr.

MARK M. MILLS, Washington; 4 deputy director of the University of California's Radiation Laboratory, Livermore Branch, and professor of nuclear engineering in the Division of Mechanical Engineering at Berkeley; member of the Atomic Energy Commission's Reactor Safeguard Committee, and member of the Advisory Committee on Atomic Energy of the Secretary of Defense; 7 Apr.

VICTOR C. PEDERSEN, Forest Glen, Md.; 90; physician and surgeon in New York until his retirement in 1948; for 15 years chief of clinic at St. Mark's Hospital in New York, where he developed one of the first social study clinics on the effects of hereditary syphilis in families; 9 Apr.

JOSEPH J. SCHAEFER, New York, N.Y.; 59; consulting chemist; 11 Apr.

BURGESS SMITH, Rochester, N.Y.; 83; chief chemist and research director of the Todd Company in Rochester until he retired in 1950; 14 Apr.

ROBERT S. WITHROW, Minneapolis, Minn.; biophysicist, and chief of the Division of Radiation and Organisms at the Smithsonian Institution in Washington, D.C.; 8 Apr.

Book Reviews

Research in Photosynthesis. Papers and discussions presented at the Gatlinburg Conference, October 25–29, 1955, sponsored by the Committee on Photobiology of the National Academy of Sciences–National Research Council and supported by the National Science Foundation. H. Graffron, C. S. French, R. Livingston, E. I. Rabinowitch, B. L. Strehler, and N. E. Tolbert, Eds. Interscience, New York, 1957. xiv + 524 pp. Illus. $12.

The National Science Foundation has now sponsored two general meetings on photosynthesis, both held in Gatlinburg, Tennessee. The first one, in November 1952, covered all aspects of the subject, but unfortunately the proceedings of that first conference were never collected and published in any single place. In this volume are not only the 67 papers which were presented at the second conference on photosynthesis but also transcriptions of a major portion of the discussions which took place there; thus the volume provides for the world at large not only a record of the conference in the form of the formal papers but something of the atmosphere of the conference, which comes through in the transcribed discussion.

This second Gatlinburg conference was not intended to encompass all aspects of the subject of photosynthesis. It was supposed to be limited to papers and discussion relating to the primary photochemical act itself. Since knowledge on this particular aspect is, as yet, limited to an enormous collection of empirical observations, together with some half-dozen theories which encompass one or another area of these empirical observations, it is clear that no volume can present any coherent story beyond this. The editors of this collection, however, have done a remarkably good job of arranging the wide variety of contributions. They have done this under six principal headings, as follows: (i) "Absorption, fluorescence, luminescence and photochemistry of pigments *in vitro*"; (ii) "Absorption, scattering, fluorescence, luminescence and primary photochemical processes *in vivo*"; (iii) "Possible role of cytochromes"; (iv) "'Dark' reactions"; (v) "Kinetics, transients and induction phenomena"; (vi) "Formation and condition of chlorophyll in the living cell."

It is clear that all workers in any aspect of the field of photosynthesis will require this collection for their reference shelves, regardless of the specific area of their work. It not only gives a general impression of the status of our knowledge of the particular area, as of October 1955, but it will be of great value as a key to an enormous variety of observations to be found in the literature.

One cannot but be tempted to compare this publication with the record of a similar conference, also a second one, which was held in the Soviet Union 21–26 Jan. 1957. All that is available to us as yet as a record of this "Second All-Union Conference on Photosynthesis" is a set of abstracts. An examination of these abstracts reveals a breadth of activity, even in the limited area of the primary photochemical process, at least as great as that to be found in the present volume.

One looks forward with considerable anticipation to the records of the third conferences.

MELVIN CALVIN
Department of Chemistry,
University of California, Berkeley

The Pharmacologic Principles of Medical Practice. John C. Krantz, Jr., and C. Jelleff Carr. Williams and Wilkins, Baltimore, Md., ed. 4, 1958. xi + 1313 pp. Illus. $14.

The fourth edition of this well-known textbook is substantially larger than the first edition, which appeared in 1949. This is true in spite of the effective manner in which the authors have deleted discussion of various drugs as they have come to be used less frequently; the increase in the size of the volume reflects the growing content of this discipline.

Two new chapters have been added, one on "Use of drugs in the treatment of mental illness" and the other on "The local use of drugs in the ear, eye, nose, and throat." Other chapters, especially those on the treatment of bacterial diseases and of hypertension, arthritis, and diabetes, have been expanded appreciably.

This book is for all students of the medical sciences. It is less comprehensive than some texts commonly employed, but the material has been well chosen, and many summary tables help to reduce the length. Most structural formulae are given, and illustrations are frequent. Historical developments in the field are presented along with portraits of important investigators. The chapter on the response of cells to drugs is particularly interesting to the professional pharmacologist, and the attempts to explain drug actions in terms of intracellular enzyme reactions provides a nice correlation of pharmacology with biochemistry.

The references at the end of each chapter are well selected, although the authors make no attempt to be comprehensive. Most of the drug preparations that are officially listed in the United States Pharmacopeia and the British Pharmacopeia are given, with the recommended dosages.

PAUL K. SMITH
Department of Pharmacology,
George Washington University
School of Medicine

Geography in the Twentieth Century. A study of growth, fields, techniques, aims and trends. Griffith Taylor, Ed. Philosophical Library, New York; Methuen, London, ed. 3, 1957. xi + 674 pp. Illus. + plates. $10.

This work, now in its third edition, offers an imposing array of essays on various aspects of contemporary geography, by 22 authors. Unfortunately, it fails of being "a study of growth, fields, techniques, aims, and trends" in any comprehensive sense. What it does provide is a mixture of the good and the bad in contemporary geographic thought.

The book is divided into three parts. The first, "Evolution of Geography and its Philosophic Basis," includes useful chapters on 19th-century geography and on French, German, and West Slavic contributions to the field. Unaccountably, the English-speaking world is not discussed. An excellent paper by G. Tatham on the environmentalist-possibilist controversy, pointing out the fallacies of environmentalism, concludes the section. The second part, although entitled "The Environment as a Factor," deals with such diversified topics as geomorphology, climatology, land use surveys, exploration, and the tropics, and by no means defines "the environment as a factor"—if, indeed, this is capable of definition. Karl J. Pelzer's chapter on "Geography and the tropics" is perhaps the high point in the book. The third section, "Special Fields of Geography," samples a number of fields, providing rather spotty coverage of the discipline.

The third edition differs from the preceding one in few respects. A reprint of

H. C. Darby's stimulating and authoritative paper, "The relations of geography and history," has been added, and Taylor's chapter on the exploration of Antarctica has been brought up to date, or nearly so.

As a reference work, the volume is distinctly useful. A reader desiring a brief summary of contemporary thought in geomorphology, climatology, historical geography, applied geography, cartography, and other such fields will find these fields well covered in the book. If, however, he is looking for a general overview of geography, of its breadth of scope, its aims, philosophy, and advancing frontiers, he should seek elsewhere: the volume, almost totally lacking in *Zusammenhang*, fails to provide a comprehensive and coherent view of the science.

The nongeographer would be well advised, therefore, to avoid reaching any conclusions about the status and accomplishments of this science from evidence found in this book. For one thing, a wholly anachronistic bias toward environmentalism underlies many of the contributions, notably those of Huntington, Visher, and, particularly, the editor himself. For another, systematic fields of human geography are not adequately covered. In sum, it can be said that the value of this work—and it is considerable—lies rather in the many useful essays it contains than in the character of the work as a whole.

JAMES M. BLAUT
Department of Geography,
Yale University

Chemical Engineering in the Coal Industry. An international conference organized by the National Coal Board, Great Britain, June, 1956. Forbes W. Sharpley, Ed. Pergamon Press, London and New York, 1957. v + 141 pp. $8.50.

Due to the need to use the lower grade coals and also to produce a more nearly smokeless domestic fuel it has become increasingly important to upgrade these fuels by means of chemical engineering. In this volume there are seven technical papers, three by British authors, three by French authors, and one by a German, with an opening address by A. H. A. Wynn and a closing address by J. Bronowski, both of Great Britain. There is considerable discussion following each paper.

The conference considered various methods for developing suitable ways to produce a good low-smoke briquette suitable for domestic use. In the several papers the authors cover controlled oxidation and fluid oxidation of coal, carbonization of briquettes, hot briquetting, and semicarbonization, as well as tars that have been obtained and how to treat low-temperature tars. In Great Britain, the problem is the need for efficient fuels for heating "fourteen million grate-heated houses"; in France, the production of good coke from coals which do not produce coke; in Germany, the production of special briquettes for smelting; while here in the United States it is the improvement of techniques for liquefying our coals, as in South Africa.

To sum up, this book urges us to use coal for the production of better fuels instead of the production only of heat and smoke.

E. WILLARD BERRY
Department of Geology,
Duke University

Our Nuclear Future. Facts, dangers and opportunities. Edward Teller and Albert L. Latter. Criterion Books, New York, 1958. 184 pp. Illus. $3.50.

The first part of this book is a straightforward and engaging account of factual scientific material on nuclei and nuclear energy. The second part is something else again. Edward Teller is noted for the imaginativeness of his ideas and the intensity of his feelings and opinions. The last half of this book is concerned with material of a more political nature, regarding which Teller's opinions, like those of anyone else, can hardly be subjected to scientific tests of validity. It is perhaps a hazard for the uninformed reader, who may expect that the latter part of the book, like the first part, will give him a careful, balanced, objective account. With chapter 8, on "Action of radiation on matter," the noncontroversial and completely objective account ends. The subsequent part of the book does contain a good deal of equally objective material; but in addition, and in spite of the evident attempt of the authors to present both sides of many highly controversial questions, their strong belief that weapon development and testing must be continued not only is explicitly stated but also unfortunately results in severe coloring of the factual material involved.

Teller himself has stated that it is impossible to discuss these problems in a short space and that therefore he was, with Latter, writing a book on the subject. It is clearly also impossible to take up, in this short space, the very large number of instances where I find the authors' presentation and approach to be severely incomplete, illogical, or misleading. But one must give at least one example. The following illustrates the point.

In a discussion concerning the fact that the radiation dose to the average individual from fallout is so small that it cannot produce any statistically detectable increase in leukemia, which is true, data are given in so unscientific a way as to be most unworthy of two such capable scientists as the authors. The data give the leukemia incidence in Denver, New Orleans, and San Francisco as 6.4, 6.9, and 10.3 new cases, respectively, per 100,000 population, for a single year. These data are then used to indicate that the extra cosmic radiation received by an individual in Denver as compared with the other cities does not produce any measurable increase in leukemia. The authors go even farther to discuss possible explanations for the "lower incidence of leukemia" (and of bone cancer: the corresponding numbers given are 2.4, 2.8, and 2.9) in Denver—for example, that "disruptive processes like radiation are not necessarily harmful in small enough doses." How improper it is to base their discussion on these data! It is clear that these data are so poor that they should not have been used at all. If given at all, the numbers should have been given in some such terms as 6.4 ± 1.3, 6.9 ± 1, and 10.3 ± 1.5. (These statistical uncertainties follow from the sample sizes involved.) And if one asks how much additional leukemia might be expected from the extra cosmic radiation in Denver, the answer, calculable from data given elsewhere in the book, would be that the 6.4 ± 1.3 would be expected to be about 6.35 ± 1.3 were it not for the excess of cosmic radiation over that at sea level.

We all owe a very considerable debt to Teller for his contributions to the defense of the country. But his current views on the necessity of weapon development, and on the attendant questions of tests and fallout, are sharply disagreed with by a very large number of his fellow scientists. It would be most desirable for him to debate these matters, directly and as calmly as possible, with dissenters. If he would submit his arguments to the searching interrogation of these of his colleagues, it is possible that his great originality might be better directed toward the most constructive solutions to the problems which face the world.

W. SELOVE
Department of Physics,
University of Pennsylvania

Histology. Arthur W. Ham. Lippincott, Philadelphia, ed. 3, 1957. xv + 894 pp. Illus. $11.

This third edition of Ham's *Histology* continues the standard of excellence which characterized the two earlier editions. Excellence of organization and unusual clarity of expression make this textbook one to be read for pleasure as

well as information. Dr. Ham has presented the voluminous material in such an understandable manner that the book is admirably adapted for use at the undergraduate level as well as in the medical school.

New features of this edition include a superb discussion of the modern concepts of the ultrastructure of protoplasm, including an excellent collection of electron micrographs; a section on microscopy, including treatment of phase contrast, interference, and electron microscopes; and discussion of work on tissue culture and transplantation of tissues. The text material has been brought up to date with considerable revision of the sections on basement membranes, blood clotting, cartilage, bone, and teeth. Throughout the text the inseparable unity of structure and function is emphasized. Each chapter has an excellent bibliography, with many references from the recent literature.

Ham is certainly to be commended for accomplishing the near-impossible—producing an up-to-date, accurate, comprehensive work so clearly written as to be readily understood by the biologist with a minimum of background.

J. R. C. BROWN

University of Maryland

The Faunal Connections Between Europe and North America. Carl H. Lindroth. Foreword by P. J. Darlington. Wiley, New York; Almquist & Wiksell, Stockholm, Sweden, 1957. 344 pp. Illus. $15.

P. J. Darlington, himself the author of a recent and very important general work on world zoogeography, has, I think, accurately summarized in his foreword the contribution of Lindroth's book. He says in effect that it has added significantly to our understanding of the content and history of the best-known northern faunas of the earth, those of Europe and eastern North America. Darlington observes, too, that its author is eminently qualified for his task, since he occupies the unique position of one having more first-hand knowledge of the beetle faunas of both continents than anyone else. This from one who is himself an eminent zoogeographer and outstanding student of Coleoptera should recommend the examination of the present book to any interested biologist.

According to Lindroth, his purpose in writing is to explain how species of certain animal groups came to occupy areas of both continents. In treating the problem he finds opportunity to discuss a number of contingent matters, some quite controversial, that have proved to be of enduring interest for the systematist and zoogeographer.

His most trustworthy materials certainly include the entomological records that he has personally amassed or for which he can vouch. Many of these are new. For animals other than beetles he generally utilizes information available in the literature or supplied by American and European specialists.

His survey of mammals, birds, fishes, many kinds of insects, spiders, myriapods, terrestrial isopods, gastropod molluscs, and lumbricid oligochaetes leads him to believe that not less than 5000 species of such organisms are known to be common to Europe and eastern North America. Of these, about 500 species are apparently indigenous to both, but these latter are largely or entirely circumpolar, or disjunct circumpolar, in distribution. Then how is the existing distribution of those remaining to be explained? Lindroth believes that introduction by human agency or by overseas dispersal (by flight, wind, on floating debris, and so on) can account for most of these.

He suspects that if continental drift ever occurred, it took place too long ago to have had any discernible effect upon the disposition of present-day faunas. In any event he suggests that modern distributions for the most part are understandable without our having to postulate a direct continental connection between Europe and America at some past time.

Similarly, even if there were good geological evidence for a complete trans-Atlantic land bridge, on the basis of existing distributions he feels it unncessary to postulate one. At the same time his appraisal of the Greenland-Iceland faunas leads him to believe that a dryland corridor of dispersal probably connected them with Europe during the Pleistocene.

Of particular interest for those of us especially interested in soil animals is Lindroth's detailed analysis of the beetle-myriapod-isopod fauna of Newfoundland. He presents quite a plausible explanation for the surprising fact that the fauna of Newfoundland, which is geographically part of North America, is predominantly European. Lindroth learned that, as early as the 17th century, vessels had begun to sail with earthen ballast from southwestern England to Newfoundland where the ballast was discharged ashore and where fish and lumber were taken on for Continental and English ports. Since the ballast usually was carried westward to Newfoundland, and not eastward to Europe, we have a plausible explanation for the occurrence of so many European insects, myriapods, and isopods in both places without a comparable representation in both of New World species. Evidently Lindroth investigated this possibility with great care, supporting his theories with information gleaned from old sailing records and with collections that he made at known ballast dumps around English and Newfoundland ports. Since ships laden with ballast and agricultural produce also sailed from Europe to the mainland of eastern North America and the Pacific Northwest, it is not difficult to find an explanation for the often spotty appearance of European species in each, especially where the climate is comparable to that of Europe.

Clearly Lindroth has gone to considerable pains to extract from his considerable direct knowledge of the Eur-American beetle faunas some cautious though warranted conclusions. One has the feeling that these first-hand data really form the nucleus of his thesis and that he explores the distributions of other animals to augment or fortify the former. A survey of such scope inevitably includes errors of omission and misidentification, especially since the author had to rely upon secondary sources of information for data on some of the insects and other animals. For instance, as a specialist in Myriapoda, I can say confidently that his list of Eur-American myriapods is neither complete nor entirely accurate. On the other hand, it seems to me that he could come to many or most of the same conclusions on the firmer ground of the Coleoptera alone. As Darlington points out, when Lindroth writes of Eur-American beetles, he has no peer.

The format of the book—its numerous good maps, graphs, and tables—assists the reader to gain a clear picture of the author's text. Following each chapter there is an extensive bibliography. Finally, it is a pleasure to say that Lindroth's writing is direct and lucidly uninvolved. He orders his arguments neatly. His style, plus the fine maps and other aids, makes reading this book quite a pleasurable as well as rewarding experience.

R. E. CRABILL, JR.

Smithsonian Institution, Washington, D.C.

Bergey's Manual of Determinative Bacteriology. Robert S. Breed, E. G. D. Murray, and Nathan R. Smith. Williams & Wilkins, Baltimore, ed. 7, 1957. xviii + 1094 pp. $15.

The sixth edition of "Bergey" (1948) was one 1500-page volume. This edition appears in two volumes, the one indicated above and an *Index Bergeyana,* to appear later. The *Index* will include most of the "*species incertae sedis,*" the literature index, and the host and habitat indices. (The "*species incertae sedis*" in the previous edition for Micrococcaceae alone numbered almost 800 and occupied 37 pages of text.) Space thus ob-

tained makes possible a more usable book, containing, actually, additional material pertinent to the recognized taxa. A significant change is the omission of the "Small viruses," order Virales, in the present edition. An addition is a 45-page "Comprehensive key to the genera of the manual," prepared by V. B. D. Skerman.

Many changes have been made in the text. Class Schizomycetes now has ten orders instead of five; family XI—Parvobacteriaceae—of the sixth edition is gone, and in its place we have family V—Brucellaceae; formerly six species of the genus *Diplococcus* were listed, now one is listed; 93 species of the genus *Clostridium* are now listed, instead of 61; *Staphylococcus albus* is absent, and so on. The new names and the changes will add to the confusion which is altogether too prevalent among microbiologists with regard to taxonomy. However, it seems to me that the changes made are clearly indicated and based on mature decisions of experts. The net result should be a need for less change in future editions and a very real advance in our understanding of microbes.

The authors are to be congratulated on a superb task well done. The book is of course highly technical, but, after hours spent going over it, I have yet to find a printing error. "Bergey's Seventh" is recommended to all microbiologists, but each who takes it up must be prepared for the feeling of entry into a slightly different world and advised not to put the book aside until it has been well examined. The work of preparing the book has been shared by many, but all will agree that this edition stands in a particular way as a monument to Robert S. Breed, deceased 10 February 1956.

LELAND W. PARR
Bacteriology, Hygiene, and Preventive Medicine,
George Washington University

Zinsser Bacteriology. David T. Smith and Norman F. Conant, Eds. Appleton-Century-Crofts, New York, ed. 11, 1957. xiii + 953 pp. Illus. $12.

A textbook of bacteriology, appearing five years after a previous edition, requires extensive revision, especially if the over-all length is not to be increased. The authors (this includes, in addition to Smith and Conant, other members of the faculty of Duke University School of Medicine: Beard, Willett, Overman, Brown, Sharp, and Poston) were well aware of this requirement. They have remained faithful, however, to the original purpose of Zinsser's textbook and have emphasized the medical and public health aspects of bacteriology. Thus, the section on physiology of microorganisms, with the exception of bacterial genetics, has not been greatly enlarged. The chapters on immunology have been arranged in a more logical sequence and have been expanded. A chapter on immunohematology has been added. The sections on pathogenic bacteria and medical mycology have been reduced for the benefit of the section on viruses.

Numerous illustrations have been added, especially in the section on viruses. The book is well written and illustrated and remains a basic text for medical students and medical bacteriologists.

EMILIO WEISS
Virology Division,
Naval Medical Research Institute

Artificial Stimulation of Rain. Proceedings of the first Conference on the Physics of Cloud and Precipitation Particles. Held at Woods Hole, Massachusetts, 7–10 Sept. 1955. Helmut Weickmann and Waldo Smith, Eds. Pergamon Press, New York and London, 1957. xvi + 427 pp. Illus. $15.

The contents of this book are described in the subtitle, "Proceedings of the first Conference on the Physics of Cloud and Precipitation Particles," rather than in the featured title. Of the 49 formal papers included in this impressive volume, only two or three treat somewhat directly certain aspects of artificial stimulation of rain, and even these do not answer questions likely to be uppermost in the minds of general readers—for example, what practical results have been attained in man's efforts to increase rainfall by cloud seeding or other artificial means? The present answer to this general question may be summed up in the words used by the author of one of the papers with particular reference to his own experiments in cloud seeding. He said: "Those are the results. We would be glad if some statistician could tell us exactly what they mean. The *only conclusion* [italics added] that we have drawn from them so far is that they justify a repetition of the experiment in 1955." Moreover, most of the technical papers in the volume reveal by inference how relatively little man knows about the physical processes of formation of hydrometeors. Urgent indeed is the need for basic research in clouds and precipitation.

For the most part the papers are by scientists who have been engaged in research in cloud physics and related subjects. They present some of the latest results of competent studies in the laboratory and in the free air. An interesting feature is the discussion that follows most of the papers. The questions and answers bring out views of many of the leaders in experimental cloud physics in North America. They show the many complex facets of this broad subject.

The papers are organized around four main headings. Part 1—Aerosols: their origin, distribution, and measurement. Part 2—Condensation and coagulation: measurement of cloud and rain-drop size; rain from water clouds. Part 3—Melting and freezing: studies of snow and ice in the generation of precipitation. Part 4—Crystal growth and nucleation: laboratory and field studies. Two shorter sections treat thunderstorm electricity and international terminology (definitions of hydrometeors)—the latter made complicated by the diversity of precipitation phenomena and the international scope of applied meteorology. Among the subjects taken up in the different articles are mechanics of droplet growth by condensation, collision, and coalescence; the composition, distribution, and meteorological role of condensation and freezing nuclei; supercooling of water droplets (a phenomenon somewhat peculiar to precipitation physics); crystallography of snowflakes and ice clouds; the effects of chemicals in facilitating and inhibiting nucleation of clouds; and use of radar and other instruments in studying cloud physics.

As a whole, the papers collected in this volume are devoted to the problems one would expect would be discussed by research scientists brought together to consider the present state of knowledge of cloud physics and implied applications to modification of clouds and precipitation. The book does not have a subject index, but the convenient table of contents makes it fairly easy to find desired material. It contains extensive bibliography lists and should be a valuable reference source for the researcher, for the student, and for the layman interested in learning more about this field and its widening possibilities.

F. W. REICHELDERFER
U.S. Weather Bureau,
Washington, D.C.

The Fishes of Ohio. Milton B. Trautman. Ohio State University Press, Columbus, 1957. xvii + 683 pp. Illus. $6.50.

Dr. Trautman of Ohio State University has devoted his life, since 1925, to study of the fishes of Ohio. In this book, the glacial history is followed by a description of the replacement of the original habitat with a dense human population and the drastic changes that have taken place in the fishes and other wildlife.

There are sections on artificial keys, equipment for identification, methods of collecting, counting and measuring, comparisons between waters, hybridization,

and factors affecting distribution of fish. There is also a glossary of technical terms. The line drawings are excellent, but the seven color plates are not of the quality of the rest of the book. For each of the 172 species there is a line drawing, spot map of Ohio, range map of North America, list of characters for identification, and description of habitat.

The scientific and common names are strictly up to date. This excellent book fills a particular need for the biologist and sportsman in Ohio and neighboring states and is very useful as a reference for anyone interested in North American fresh-water fishes.

HURST H. SHOEMAKER

Department of Zoology, University of Illinois

New Books

Mass Spectroscopy. Henry E. Duckworth. Cambridge University Press, New York, 1958. 223 pp. $6.50.

Erythroblastosis Fetalis. Including exchange transfusion technic. Fred H. Allen, Jr., and Louis K. Diamond. Little, Brown, Boston, 1957 and 1958. 153 pp. $4.

The Story of Life. H. E. L. Mellersh. Putnam's, New York, American ed. 1, 1958. 263 pp. $3.95.

Mathematical Foundations of Information Theory. A. I. Khinchin. Translated by R. A. Silverman and M. D. Friedman. Dover, New York, 1957. 120 pp. $1.35.

Three Dimensional Dynamics. A vectorial treatment. C. E. Easthope. Academic Press, New York; Butterworths, London, 1958. 285 pp. $7.80.

Psychotherapy of Chronic Schizophrenic Patients. Carl Whitaker. Little, Brown, Boston, 1958. 229 pp. $5.

Surface Chemistry. Theory and applications. J. J. Bikerman. Academic Press, New York, ed. 2, 1958. 511 pp. $15.

Biology Serving You. Charles Gramet and James Mandel. Prentice-Hall, Englewood Cliffs, N.J., 1958. 623 pp. $4.96.

Organic Electrode Processes. Milton J. Allen. Reinhold, New York; Chapman & Hall, London, 1958. 188 pp. $6.50.

Physics of Fission. Supplement 1 of *Soviet Journal of Atomic Energy.* S. M. Popova, Ed. Consultants Bureau, New York, 1957. 140 pp. $30.

A Laboratory and Field Manual of Ornithology. Olin Sewall Pettingill, Jr. Burgess, Minneapolis, ed. 3, 1956. 379 pp. $5.

Macromolecules in Cell Structure. A. Frey-Wyssling. Harvard University Press, Cambridge, Mass., 1957. 119 pp. $5.

A History of Magic and Experimental Science. vols. VII and VIII, *The Seventeenth Century.* Lynn Thorndike. Columbia University Press, New York, 1958. 705 pp.; 816 pp. $10 per volume.

Logical Design of Digital Computers. Montgomery Phister, Jr. Wiley, New York; Chapman & Hall, London, 1958. 424 pp. $10.50.

Biological Aspects of Cancer. Julian Huxley. Harcourt, Brace, New York, 1958. 156 pp. $3.75.

Handbuch der Physik. vol. 5, pt. 1, *Principles of Quantum Theory I.* 376 pp. DM. 90. vol. 50, *Astrophysics I.* 465 pp. DM. 98. S. Flügge, Ed. Springer, Berlin, 1958.

Oil Reservoir Engineering. Sylvain J. Pirson. McGraw-Hill, New York, ed. 2, 1958. 745 pp. $14.

The Theory of Thermal-Neutron Nuclear Reactors. pts. 1 and 2, supplements 2 and 3 of *Soviet Journal of Atomic Energy.* English translation. A. D. Galanin. Consultants Bureau, New York, 1958. 187 pp.; 291 pp. $60.

Methods in Medical Research, vol. 7. James V. Warren, Ed. Year Book, Chicago, 1958. 250 pp. $7.50.

Progress in Biophysics and Biophysical Chemistry. vol. 8. J. A. V. Butler and B. Katz, Eds. Pergamon Press, New York and London, 1957. 417 pp. $17.50.

A Treatise on Plane and Advanced Trigonometry. E. W. Hobson. Dover, New York, ed. 7, 1957 (republication of the 1928 edition of *A Treatise on Plane Trigonometry*). 398 pp. $1.95.

Introduction to Fourier Analysis and Generalised Functions. M. J. Lighthill. Cambridge University Press, New York, 1958. 87 pp. $3.50.

British Pharmacopoeia, 1958. Published under the direction of the General Medical Council. Pharmaceutical Press, London, 1958 (order from Rittenhouse Bookstore, Philadelphia, Pa.). 1038 pp. £3 3s.

Chemical Reaction Engineering. Twelfth meeting of the European Federation of Chemical Engineering, Amsterdam, 7–9 May 1957. Pergamon Press, New York and London, 1957. 208 pp. $12.50.

Chemistry of Lipides as Related to Atherosclerosis. A symposium. Irvine H. Page, Ed. Thomas, Springfield, Ill., 1958. 351 pp. $8.50.

Concepts, Theories, and the Mind-Body Problem. vol. II. Minnesota Studies in the Philosophy of Science. Herbert Feigl, Michael Scriven, Grover Maxwell, Eds. University of Minnesota Press, Minneapolis, 1958. 568 pp. $7.

Decision Making. An experimental approach. Donald Davidson and Patrick Suppes in collaboration with Sidney Siegel. Stanford University Press, Stanford, 1957. vi + 121 pp. $3.25.

Electronic Theories of Organic Chemistry. An introductory treatment. John William Baker. Oxford University Press, New York, 1958. vii + 224 pp. Illus. $4.80.

Electrons at Work. F. J. M. Laver. Oxford University Press, New York, 1957. Illus. 7s. 6d.

Basic Concepts in Chemistry. George W. Watt. McGraw-Hill, New York, 1958. 545 pp. $6.50.

Les Hétérocycles Oxygénés. Colloques Internationaux du Centre National de la Recherche Scientifique. No. LXIV. Centre National de la Recherche Scientifique, Paris, 7, 1957. 390 pp. F. 2500.

Systematic Sociology. An introduction to the study of society. J. S. Eros and W. A. C. Stewart, Eds. Philosophical Library, New York, 1958. 178 pp. $6.

Fundamentals of Neurology. Ernest Gardner. Saunders, Philadelphia, ed. 3, 1958. 399 pp.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

UNESCO Symposium on Physical Oceanography, Proceedings. Tokyo, 1955. UNESCO and Japan Society for the Promotion of Science, Tokyo, 1957. 292 pp. $4.50.

Proceedings of the Fourth Annual Computer Applications Symposium, 24–25 Oct. 1957. Armour Research Foundation of Illinois Institute of Technology, Chicago, 1958. 126 pp. $3.

Selected Scientific Papers from the Istituto Superiore di Sanità. vol. I, pts. 2 and 3. Fondazione Emanuele Paternò, Rome, Italy, 1956 (order from Interscience, New York). 310 pp. $8.10, each.

A Revision of the Genus Chaetocalyx. Contributions from the U.S. National Herbarium, vol. 32, pt. 3. Velva E. Rudd. Smithsonian Institution, Washington, 1958. 38 pp.

The Acanthaceae of Colombia, III. Contributions from the U.S. National Herbarium, vol. 31, pt. 3. Emery C. Leonard. 459 pp. Paper, $1.75. *Life Histories of North American Blackbirds, Orioles, Tanagers, and Allies.* Order Passeriformes: Families Ploceidae, Icteridae, and Thraupidae. U.S. National Museum Bull. 211. Arthur Cleveland Bent. 557 pp. Paper, $2.25. Smithsonian Institution, Washington 25, 1958 (order from Supt. of Documents, GPO, Washington 25).

Foundations' Fund for Research in Psychiatry. Report of grant activities for the year ending 30 June 1957. The Foundation, New Haven, Conn., 1958. 35 pp.

Laboratory Studies in Integrated Zoology. Cleveland P. Hickman and Frances M. Hickman. Mosby, St. Louis, 1957. 353 pp. $3.75.

Research and Education in Meteorology. An interim report of the Committee on Meteorology. National Academy of Sciences–National Research Council, Washington, D.C., 1958. 69 pp.

Common Fleshy Fungi. Clyde M. Christensen. Burgess, Minneapolis, rev. ed., 1955. 246 pp. $3.

Librarian of Congress, Annual Report. For the fiscal year ending 30 June 1957. Library of Congress, Washington 25, 1958. 167 pp.

Anuário do Observatório do S. Paulo para 1958. Instituto Astronômico e Geofísico, Universidade de São Paulo, São Paulo, Brasil, 1957. 91 pp.

Insects of Hawaii. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. vol. 6. Ephemeroptera-Neuroptera-Trichoptera and Supplement to volumes 1 to 5. Elwood C. Zimmerman. University of Hawaii Press, Honolulu, T.H., 1957. 218 pp. $4.50.

A Study of the Chironomidae (Diptera) of Africa South of the Sahara. pt. III. Bulletin, Entomology, vol. 5, No. 9. Paul Freeman. 106 pp. 30s. *New and Little-Known Species of African Trichoptera.* Bulletin, Entomology, vol. 6, No. 1. D. E. Kimmins. 38 pp. 10s. British Museum (National History), London, England, 1957. 10s.

Reports

Distinctive Type of Primitive Social Behavior among Bees

The purpose of this paper (*1*) is to describe a type of social behavior which we believe to be important in understanding the evolution of societies in higher bees. It is found in *Augochloropsis sparsilis* (Vachal) [Hymenoptera, Halictidae]. Our observations were made in the Bariguí roadside banks (*2*) near Curitiba, Paraná, Brazil, during the year July 1955–June 1956.

One of us has explained elsewhere (*3*) his conviction that social organization in the main groups of social bees (Halictinae and Apinae) did not arise, as it probably did in wasps and ants, through subsocial family groups in which a parent protects and feeds her larval offspring. This notion has been prevalent in the literature (*4*) due to evidence for care of larvae by adults of the bee genera *Allodape* and *Exoneura*. However, in all Halictinae and all but some specialized Apinae (such as *Apis*), the larval cells are closed; care of larvae during their growth is therefore impossible, and the subsocial family group becomes an unlikely antecedent to specialized social behavior with division of labor, caste differentiation, and so forth. Such specialized behavior occurs in certain groups of both Halictinae and Apinae, and steps in its establishment are said (*3*) to include the following: (i) nest aggregations; (ii) use of a common nest by several females, each of which constructs and provisions her own cells; (iii) initiation of division of labor and cooperation among such females; and (iv) differentiation of the females into queens and workers and establishment of a numerical preponderance of females over males.

Step i is well known (*2*). Step ii has been often reported and recently has received considerable attention (*5*). Step iv is of course well known in such groups as *Bombus,* the Meliponini, and *Apis,* and less well known in the social Halictinae (some species of *Lasioglossum, Halictus,* and so on). The importance of *Augochloropsis sparsilis* is that, unlike other bees for which details of the bionomics are known, it is a convincing example of stage iii, a status that may be called semisocial.

Each nest consists of a burrow extending into the bank and ending in one or several groups of adjacent cells. Each nest is ordinarily occupied by several female bees. The males leave the nests soon after emergence, and mating probably takes place elsewhere. The number of females per nest fluctuates with the season, as shown in Fig. 1 (bottom). The interrelations among these females are of primary interest in this study.

As the nests are used year after year, if they are not destroyed by erosion of the banks, it seems likely that the inhabitants of a nest are commonly sisters. However, it is apparent that this need not be the case, since we have found two and three females together in a simple burrow without cells; evidently when a female starts a burrow she may be joined by others which are not likely to be her sisters.

From observations of marked individuals we know that females of various ages go into the winter. The badly worn and tattered bees disappear in the fall, but some bees several months old, although still unworn or nearly so, overwinter with young unworn females. In the spring, all bees therefore start activity with relatively unworn mandibles and wings. Soon, however, some individuals become worn, and from that time on until late fall the population of females consists of a mixture of tattered and fresh individuals in various proportions (Fig. 1, top). In each nest there are usually, after early spring, individuals exhibiting considerable wear, as well as fresh and intermediate ones. This indicates diversity in activity among the females concerned. Mandibular wear must occur in the nest, while wing wear occurs in the field, probably around flowers. Bees that show one type of wear ordinarily show the other also; this indicates that bees that work ordinarily engage in both outside and inside activity.

Figure 1 (middle) shows that while all overwintering females have very slender ovaries (less than 0.25 mm wide) or slender ovaries (0.26 to 0.45 mm wide), great diversity in ovary size soon develops and persists throughout the egg-laying season. Ovaries which are much swollen (0.86 to 1.20 mm wide) almost invariably contain one or more oocytes 1.5 mm long or longer, and usually they contain one larger one, which approaches the size of a fully developed egg cell (about 3 mm long). No new bees reach maturity until January (the southern summer). Therefore, as Fig. 1 (middle) shows, an increasingly large percentage of the overwintering bees reach egg-laying condition during the spring and early summer. Although a few (2.4 percent of 85 dissected) females have much-swollen ovaries while their wings and mandibles are still unworn, in general such ovaries are associated with wear. Seemingly most bees have done some work by the time they become egg layers. Among 241 females dissected during the year, 14.9 percent had much swollen ovaries and were therefore considered egg layers, but during November and the summer months when egg laying is at a maximum, 20 to 30 percent of the females had much swollen ovaries.

Another aspect of the diversity among females involves pollen collecting. Observations of nests which were later excavated revealed that often in a nest containing three or four bees, only one was making pollen-collecting trips. Or, especially in a larger nest, two or three were sometimes collecting pollen simultaneously. In such cases, when the nest was opened, there was never found more than one cell being provisioned. The pollen gatherers clearly cooperate in the provisioning of cells.

Pollen gatherers normally have slender to very-slender ovaries, and, although sometimes fresh, they usually show considerable and often maximum mandibular and wing wear. We judge from this that some females develop as pollen collectors and wear out and die without ever becoming egg layers. This surmise is supported by data from marked bees. Ninety-two females were marked (*6*) with colored paints during November and January. Bees for marking were obtained during warm days as they entered their nests after trips afield. About half of the bees marked were returning to their nests with pollen loads. After a series of such bees had been marked and allowed to re-enter their nests, it was usual to see the individuals marked as pollen collectors continuing in that activity for two or three weeks, but grad-

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All technical papers are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table *or* one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

ually they disappeared. Probably death of such bees is a major factor in the diminution of nest populations noted during October, November, and December (Fig. 1, bottom). The records are few and inconclusive, but we think that as pollen collectors die, they are replaced by other, previously relatively inactive bees. Reduction in egg production during November and December (Fig. 1, bottom) as well as other data suggest that egg layers probably also die during this period and are only partly replaced from among the previously inactive bees. After the second brood begins to appear, in January, nest populations and egg production rise.

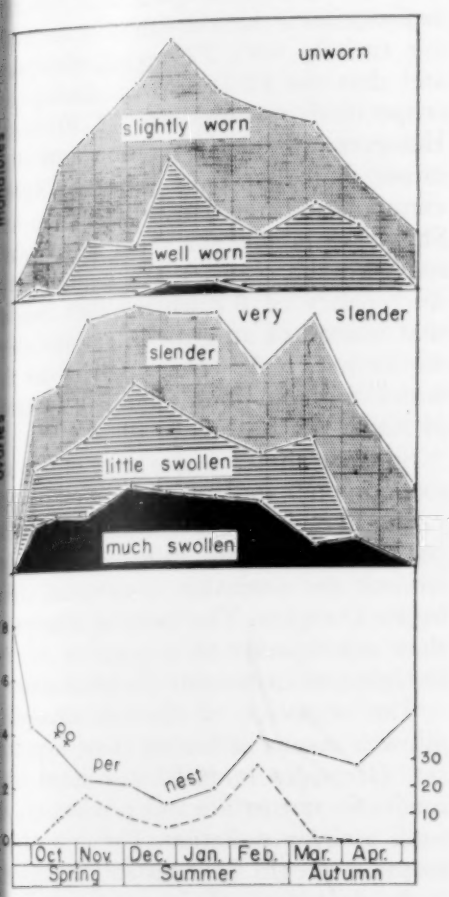

Fig. 1. Nest statistics and conditions of female occupants. (Top) The white and shaded zones vary in width according to the percentage of individuals having mandibles classified as unworn, slightly worn, well worn, and much worn. The four zones total 100 percent in vertical distance at any date. (Middle) White and shaded zones show fluctuations in percentages of females in four groups, classified according to size of ovaries. (For both these sets of percentages, the number of individuals examined was more than 20 for each date, with the exception of early October, when the number in the "middle" group was 11, and of April, when the numbers in the "top" and "middle" groups were 13 and 12, respectively.) (Bottom) Solid line shows average numbers of females per nest, plotted on the scale shown at the left (the number of nests examined, for each date, was 4 to 11, and trends were supported by data from many other nests for which we have only incomplete counts); broken line shows percentage of cells containing eggs, plotted on the scale shown at the right (the number of cells examined, for each date, was more than 40, except for April, when the number was 25).

Probably all females leave the nest from time to time to feed. Bees that become pollen collectors may do so more often, while those that become egg layers perhaps do so less often. As bees develop in one or the other of these directions, they show the results of wear, but a number of unworn bees with slender ovaries always remain in the nests. This number decreases steadily (Fig. 1, middle) until January, when new adults emerge. This indicates that bees leave this inactive state to become active either as foragers or as egg layers.

The division of labor described above occurs among bees which do not differ significantly in size, and all of which ordinarily are mated. Clearly, there is no morphological caste differentiation and, as might be expected, male progeny are little if any less numerous than female.

There are, however, a few unfertilized bees in the nests, as determined by examinations of spermathecae for spermatozoa (*6*). Among the overwintering bees dissected in spring and early summer, only one out of 86 was unmated. During January and February, between 15 and 20 percent of the females dissected were unmated; in some cases this was merely because they were young, but others showed wear and presumably would not mate. Over half of the pollen collectors studied during those months were unmated, and we think that most or all of the bees that remain unmated become pollen collectors. Like most other pollen collectors, they have slender ovaries, and usually worn wings and mandibles. Only rarely was more than one such bee found in a nest, and often there was none. Some unfertilized bees were found to be much more worn (with respect both to mandibles and wings) than any fertilized bees of the same age.

It is easy to see that the presence of such active, unfertilized bees might be an advantage to a colony, even though they are nonreproductive. We conjecture that the habit of extensive work on the part of unmated females served as a preadaptation that permitted selection for the regular occurrence of such individuals (workers) and thus provided for the establishment of a worker caste.

In summary, *Augochloropsis sparsilis* exhibits a type of social behavior in which several morphologically similar females, most or all of which mate, occupy a single nest. Division of labor is established, for some females become egg layers, others pollen collectors; cooperative activity includes joint provisioning of cells by two or three bees. A few of the females never mate; these work more than most mated bees, a fact which perhaps provides the basis on which selection can work toward establishment of a regular nonreproducive worker caste.

CHARLES D. MICHENER
Department of Entomology, University of Kansas, Lawrence

RUDOLF B. LANGE
Instituto de Historia Natural and *Faculdade Catolica de Filosofia, Curitiba, Paraná, Brazil*

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1. Preparation of this report was possible thanks to aid and travel grants from the National Science Foundation (Washington), the Guggenheim Foundation (New York), the Campanha de Aperfeiçoamento de Pessoal de Nível Superior (Rio de Janeiro), and the Rockefeller Foundation (New York) and thanks to facilities of the Universidade de Paraná, Curitiba, Brazil, provided through the courtesy of J. S. Moure, who identified the bee concerned for us.
2. C. D. Michener *et al.*, *Ecology*, in press.
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30 December 1957

Absorption of Cosmic Radio Noise during the Great Aurora of 11 February 1958

During the night of 10–11 February 1958 observers in clear portions of the United States witnessed one of the largest aurorae of the current sunspot cycle. Although heavy clouds blanketed Boulder, Colorado, two receivers normally used for measurements of the absorption of 18 Mcy/sec galactic radio noise operated throughout the night. One of these receivers recorded the total power from a vertically-beamed antenna approximately 50 by 90 deg wide between the half-power points. The other receiver measured power in a two-element, Ryle phase-switching interferometer with a baseline 16.8 wavelengths long, oriented at an azimuth 41 deg east of north. The elements of the interferometer were steerable corner reflectors with beams 40 deg wide and 60 deg high, at a fixed orientation elevated 35 deg toward the northeast. The output of the interferometer split into two channels, one recording the average power (called "total power") between the two halves of the Ryle switch axle, the other the power difference (called "phase power") between the two half-cycles.

Figure 1 shows the three records. Two principal events occurred, between 0545

Table 1. Absorption (18 Mcy/sec), February 1958, 1200 local time.

Date	9	10	11	12	13
Absorption (neper)	0.9	0.9	0.2	0.7	0.9
fOF2 (Mcy/sec) (San Francisco values)	14.1	14.2	4.7	11.4	13.2

U.T. and 0727 U.T., and between 0847 U.T. and 1025 U.T. Unfortunately, an automatic calibration interrupted the record from the vertical beam at midnight, local time (0700 U.T.).

Note the detailed correspondence of fluctuations in intensity on the two total power records. Since the antenna beams intersected the ionosphere at points located 150 or more kilometers apart over the surface of the earth, we conclude that the ionization produced by the aurora was essentially uniform over that region. Little and Leinbach (*1*) drew a similar conclusion for auroral zone absorption.

The presence of phase power, on the other hand, suggests a variation in absorption within the antenna beams of the interferometer. This conclusion is consistant with the previous conclusion on the uniformity of ionization since the phase power amounts to a small fraction (at most 30 percent, and usually much less) of the total power in the Ryle interferometer.

Curiously, the sign of the phase power remained constant throughout the aurora, as though we were dealing with a single patch of ionization that remained constant in position between two of the interference fringes. If we assume that the maximum amplitude of the phase power, in units of the total power in the interferometer, corresponds to a complete absorption of the cosmic noise over a limited cloud-like region of ionization, we may estimate the size and location of the cloud. The total beam of the corner reflectors used in the interferometer subtends roughly 2000 square degrees on the sky. Thirty percent of this area amounts to a region roughly 25 by 25 deg. The fringes of our interferometer are, in the zenith, spaced much more closely than 25 deg, and only yield spacing of as much as 10 deg near the northeast horizon. A cloud 10 by 60 deg, elongated parallel to the fringes in the low northeastern part of our pattern, explains satisfactorily all aspects of the phase power record. Finally, such a cloud corresponds quite closely to the optical phenomenon known as a quiet arc.

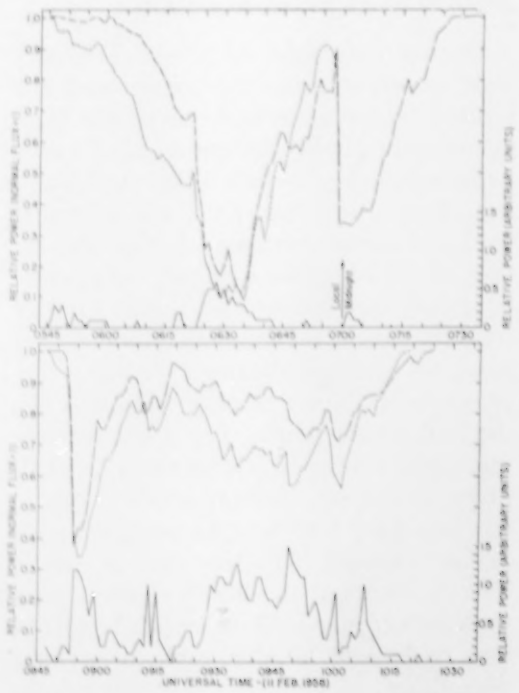

Fig. 1. Dashed line, total power in the interferometer system; broken line, power in the vertical beam (read values on the left-hand scale, normalized so that the unit is power level outside of the aurora); solid line, phase power (of constant sign) in the Ryle interferometer (read values from the right-hand scale, normalized so that the unit is 0.05 times the normal total power level).

Since the fluctuations in the amplitude of the phase power corresponded quite closely to the fluctuations appearing on the two total power records, our conclusion is that increases in the intensity of ionization in the auroral arc on 11 February 1958 strongly correlate with corresponding increases in the intensity of the ionization hundreds of kilometers away, overhead in Boulder, Colorado.

This equipment ran continuously throughout the preceding and following days. We have computed the noontime absorption (local noon is 1900 U.T.), by comparing the vertical beam records with midnight records from 6 months previously. Since the noontime fOF2 values are so high, we also corrected for an ionospheric cutoff effect of 0.13 neper, for fOF2 values of 14 Mcy/sec. The absorptions, along with the corresponding fOF2 values, appear in Table 1. The absorption was lower by 0.7 neper on 11 February, the day after the aurora, and only recovered to the normal level on the 13th.

The interferometer had been aimed toward the northeast, not to observe auroral effects, but to observe the rising of the bright discrete radio noise source, Cygnus A. Over the preceding and following days, we had found a normal pattern of rising, in which the source disappears from view between 0800 and 0900, local time. On 11 February, in contrast, the source continued to be visible until, late in the morning, it passed out of the antenna beam. This observation confirms the low value of electron density in the F-regions on that day.

Two possible explanations for the lowered absorption may be mentioned. We assume that the value 0.7 neper is the absorption normally produced by the F-region when fOF2 is 14 Mcy/sec. We extrapolate the curve, fOF2 as a function of F2 region absorption, derived by Mitra and Shain (*2*), to this critical frequency, and find only 0.5 neper. Our higher value suggests that Mitra and Shain's curve steepens at high frequencies. Our first explanation is therefore that we are dealing entirely with F2 region absorption and that the F2 layer was missing (for unspecified reasons) on 11 February. However, this interpretation runs into minor difficulty on 12 February. Again, extrapolating the curve of Mitra and Shain, we predict 0.3 neper in comparison with the observed 0.5 neper, still a discrepancy of 0.2 neper. This implies that instead of an error in extrapolation we have a scale error applying to the entire curve of absorption as a function of fOF2.

Suppose that a major part of the absorption on 9 and 10 February took place in the D-region. Our second explanation postulates that the intense aurora destroyed the ionizable constituent, NO^+, in the D-region. The lowered absorption then corresponds to a recovery of the D-region to its normal chemical state.

The statistics of diurnal absorption allow a means of testing these hypotheses. Decreases in fOF2 associated with magnetic storms are independent of the sun's ionizing radiation. The diurnal absorption should be constant throughout such decreases, if it is essentially a D-layer effect.

James W. Warwick

High Altitude Observatory, University of Colorado, Boulder

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3. This research was supported by the Electronics Research Directorate, Air Force Cambridge Research Center. Ans Pottasch and Robert H. Lee participated in the program leading to these results.

17 March 1958

Burnsi and Kandiyohi Genes in the Leopard Frog Rana pipiens

Two pattern variants of the leopard frog, *Rana pipiens*, have been found in populations from midwestern United States, particularly Minnesota (*1*, *2*). A burnsi or nonspotted variety was demonstrated by Moore (*3*) to be a simple Mendelian dominant to the common

spotted (*pipiens*) pattern. A kandiyohi or mottled deviant was shown by Volpe (*4*) to be also a simple dominant mutant of the common spotted leopard frog. Subsequent breeding tests (*5*) revealed that the genes governing the expression of the three pigment patterns may be allelic, closely linked, or located at two different, independently assorting loci.

Results of breeding tests, reported here, obtained independently in two laboratories, indicate the existence of a fourth phenotype, designated "mottled burnsi." In crosses previously reported (*5*), Volpe failed to detect the mottled burnsi class.

The methods of experimentation employed in each laboratory were essentially the same as those used in earlier work (*3–5*). The notable modification in technique was that of rearing the offspring *beyond* metamorphosis, for a period ranging from several days to 6 months. Misjudgments are not likely to occur when phenotypic determinations are made on postmetamorphic juvenile frogs rather than on newly transformed frogs or on those possessing remnants of the tail [compare Fig. 1 with Fig. 17 in Volpe (*5*)].

In the experiment conducted by Anderson, the eggs of a single kandiyohi female were fertilized in two batches, the first with sperm of a common spotted (*pipiens*) frog, the second with sperm of a burnsi frog. The former cross yielded 91 kandiyohi and 111 *pipiens* offspring, or 1:1 ($p > 0.10$). The kandiyohi female was thus heterozygous for the mottling gene. The burnsi male proved to be heterozygous for the nonspotting gene (*6*). Four patterns (Fig. 1) were recovered from the cross, kandiyohi ♀ × burnsi ♂, the numbers and phenotypes being as follows: 40 kandiyohi, 36 burnsi, 39 *pipiens*, and 32 of the type designated "mottled burnsi." The mottled burnsi offspring combines characteristics of the two mutant forms; it lacks the large dorsal spots, as does the burnsi variant, and possesses the vermiculate mottling characteristic of the kandiyohi mutant. The segregating ratio is 1:1:1:1 ($p > 0.70$), not 2:1:1, as reported previously by Volpe (*5*). The error was due to the grouping of the two classes of mottled progeny, kandiyohi and mottled burnsi, into one phenotypic class.

Volpe repeated his earlier work with the view of raising the offspring to sexual maturity (*7*). Reciprocal crosses between the mutant types were performed. The experiment was rewarding only in revealing the mottled burnsi pattern, since none of the progeny survived to maturity (this was true in the case of crosses performed by Anderson also). The segregation observed in the progeny of the cross, kandiyohi ♀ × burnsi ♂, was 15 kandiyohi: 11 burnsi: 10 *pipiens*: 14 mottled burnsi.

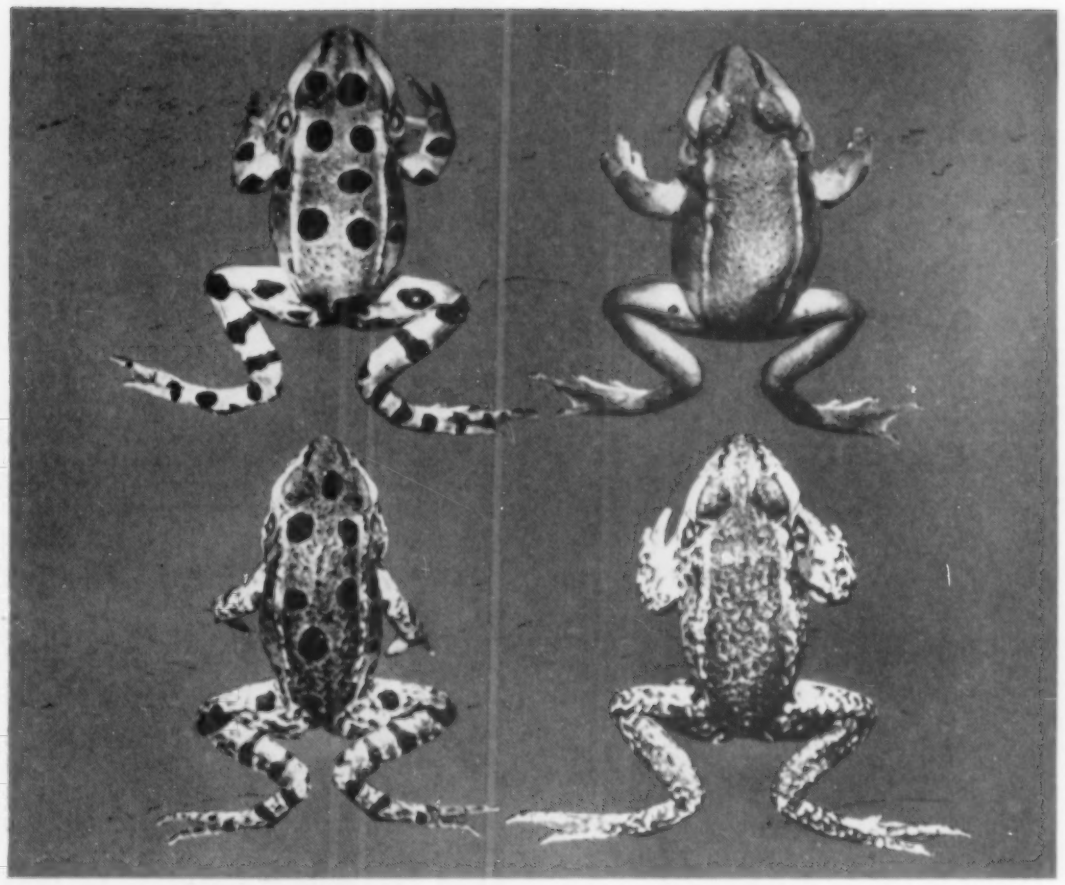

Fig. 1. Four patterns recovered in a ratio of 1:1:1:1 from a cross of a mottled (kandiyohi) with a nonspotted (burnsi) leopard frog. Offspring were as follows: common spotted or *pipiens* (upper left); nonspotted or burnsi (upper right); mottled or kandiyohi (lower left); and "mottled burnsi" (lower right).

The reciprocal cross, burnsi ♀ × kandiyohi ♂, yielded 10 kandiyohi, 7 burnsi, 8 *pipiens*, and 5 mottled burnsi. Neither of these ratios differs significantly from 1:1:1:1 ($p > 0.70$ in the former, $p > 0.50$ in the latter) (*8*). The results are interpretable on the basis that the parental kandiyohi and burnsi frogs in each cross were heterozygous.

Since experimentation beyond the F_1 still constitutes a challenge, the mode of inheritance of the pigment patterns remains problematical. The varieties may depend upon a series of multiple alleles (burnsi or nonspotted, C^B; kandiyohi or mottled, C^K; *pipiens* or common spotted, c^+). The heterozygous kandiyohi and burnsi parents in the afore-mentioned experiments would be C^Kc^+ and C^Bc^+, respectively; the mottled burnsi offspring thus would represent the compound, C^KC^B. The results can be explained equally well by assuming two pairs of alleles that assort independently or are completely linked. If we designate the kandiyohi gene *K*, burnsi, *B*, and *pipiens*, K^+ or B^+, the kandiyohi parent (in each of the above crosses) could have been either $KK^+B^+B^+$ (independent assortment) or KB^+/K^+B^+ (close linkage). Similarly, the burnsi parent could have been either $K^+K^+BB^+$ or K^+B/K^+B^+; the mottled burnsi offspring would be either KK^+BB^+ or KB^+/K^+B. Whichever of the three alternative inheritance schemes is correct, it is evident from the present data that the kandiyohi gene is neither dominant nor epistatic to the burnsi gene.

The recovery of mottled burnsi frogs in laboratory cultures raises the question of their existence in nature. The mottled burnsi frog apparently has escaped detection in natural populations or, if seen, has not been reported. Knowledge of the distribution and frequencies of the kandiyohi and burnsi mutants is incomplete; however, both variants are known to coexist in certain localities (*1, 9*). The kandiyohi and burnsi variants may be sufficiently rare as to preclude a chance meeting of the two. It may be that the mottled burnsi frogs, if produced in nature, are at a strong selective disadvantage. Population studies are in progress (*10*).

STEVEN C. ANDERSON
Division of Life Science,
University of California, Riverside
E. PETER VOLPE
Department of Zoology,
Newcomb College, Tulane University,
New Orleans, Louisiana

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2. The burnsi and kandiyohi mutants have been reported only from the midwestern area; however, the two mutant types are known to occur sporadically in Maine, Nevada, and Mexico (R. Ruibal and J. A. Moore, personal communication).

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6. All burnsi and kandiyohi adults utilized as parents in previous crosses (*3–5*) were also heterozygous. No homozygous adults of these mutant types have been uncovered in breeding tests.
7. This research was supported by a grant from the National Science Foundation (NSF-G3332).
8. We assume that there is no differential mortality among the larvae. In Anderson's kandiyohi ♀ × *pipiens* ♂ and kandiyohi ♀ × burnsi ♂ crosses, 28 percent (78 of 280) and 38 percent (92 of 239), respectively, of the larvae died prior to metamorphosis. In Volpe's kandiyohi ♀ × burnsi ♂ and burnsi ♀ × kandiyohi ♂ crosses, 33 percent (24 of 74) and 48 percent (28 of 58), respectively, of the tadpoles failed to transform.
9. Professional frog dealers in the midwest estimate (a rough approximation at best) that the kandiyohi and burnsi variants each comprise 1 percent of leopard frog populations (*3–5*).
10. D. J. Merrell at the University of Minnesota is presently engaged in a study of the mutant populations in the Minnesota-Dakotas area (personal communication).

19 December 1957

Apparent Movement of Southern Bean Mosaic Virus across Steamed Areas of Bean Stems

In 1933 Grainger (*1*) reported that tobacco mosaic virus moved across steamed areas in stems and leaves. His results conflicted, however, with those of other investigators (*2*), who also had worked with strains of tobacco mosaic virus. The view based on these papers (*2*) was that mosaic viruses do not pass steam-killed sections of stems (unless they are deliberately introduced into tracheary elements) because normally these viruses are unable to pass either into or out of tracheary elements (*3*). Apparently no evidence contrary to this latter view has since been reported either for mosaic viruses or for phloem-limited viruses (*4*), but such evidence has been reported for a xylem-limited virus (*5*).

Our study of the movement of southern bean mosaic virus (SBMV) indicates that this virus, or some part of it capable of initiating infection, can pass into, through, and out of steamed portions of Pinto bean (*Phaseolus vulgaris* L.) stems. In these steamed portions, cells that possess dehydrogenase activity or the capacity of cell division, two activities associated with living cells, could not be detected. Because evidence for this pathway of movement of presumably large particles may interest biologists in various fields, the results obtained are summarized here.

The experimental method followed is based on the fact that when SBMV is introduced into a systemic host (Black Valentine bean) previously grafted to a local-lesion host (Pinto bean) a systemic necrotic reaction associated with multiplication of the virus occurs in the latter bean (*6*). This procedure minimized the possibility of spread of virus above a steamed region unless the primary infections arose from particles that passed through the steamed area, because a systemic spread of virus does not occur with superficial inoculation of Pinto in any region (*6, 7*).

In our experimental procedure each Black Valentine bean plant, which had been previously approach-grafted between the primary leaf node and the soil line region to the same region of Pinto, was mechanically inoculated on trifoliate foliage with SBMV (Fig. 1). A cellophane barrier (not shown in Fig. 1) prevented contact between Black Valentine and Pinto plants. Inoculation was made 24 to 48 hours after a portion of the internode (an inch or more in length) above the primary leaves of Pinto was steamed. Plants thus treated are hereafter designated "grafted-steamed." Each control consisted of an inoculated Black Valentine plant tied, instead of grafted, to an adjacent Pinto. (This combination is hereafter designated "nongrafted control"). In some experiments an additional type of control, Black Valentine grafted to a Pinto (designated "grafted control"), was included. This control indicated whether virus was accidentally introduced into Black Valentine and passed the section of a stem to be steamed after a graft union was established, but before the application of steam. The Black Valentine plant of the grafted control was severed above the graft union and removed about 3 hours after inoculation. An added precaution used to eliminate the possibility of insect introduction of the virus was weekly fumigation and spraying.

Assays, made by a local lesion method (*8*), of two or three samples from tissue four and more nodes above the primary leaf node from each Pinto were used to detect the presence of SBMV (Table 1). The number of lesions resulting from the assay of samples from grafted-steamed plants (38 positive cases) ranged from 0 to 450 per leaf with a mean of 60. The number of lesions resulting from the assay of samples from control plants (4 positive cases) ranged from 0 to 4 with a mean of 0.8. The purpose of the large number of controls (three times the number of grafted-steamed plants) used in the first two experiments was to increase the probability of detection of virus that might have occurred above steamed sections in Pinto without particles having moved through the graft union.

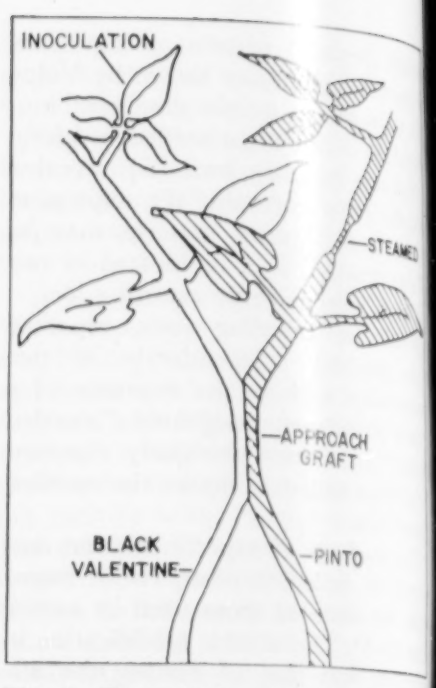

Fig. 1. The relation between the region of inoculation of southern bean mosaic virus and the steamed section in grafted bean plants.

Table 1. Detection of southern bean mosaic virus in Pinto bean plants. The numerator represents total number of Pinto plants in which virus was detected; the denominator represents the total number of plants assayed.

Expt. No.	Grafted-steamed	Non-grafted control	Grafted control
1	12/12	0/36	
2	6/12	1/36	
3	9/11	0/8	0/9
4	11/14	1/10	2/13

In addition to the detection of virus by assay of random samples, necrotic areas were noted above steamed sections in Pinto; these areas contained virus. Such necrotic areas occurred in 18 of the 38 plants in which virus was detected above the steamed portions of stems. The necrotic areas indicate that particles, after passing through steamed sections of stems, reached a cellular environment that supported multiplication. Necrotic symptoms never occurred in the control plants (112 plants).

The source of contamination (Table 1) that would explain the detection of virus in 4 out of 112 control plants is not known. The low virus level and low frequency of this contamination, however, do not account for the frequent high level of virus and the characteristic systemic necrotic symptoms that resulted only on the Pintos of grafted-steamed plants above steamed portions of stems. These symptoms occurred 12 to 36 inches above steamed portions in most cases. As a previous statement in this paper indicates, such a spread of SBMV would not occur from an accidental contamination since this is equivalent to a superficial inoculation of Pinto (*6, 7*).

The steamed sections were studied in

the following ways to determine whether they contained living cells that might support multiplication of SBMV: (i) by determining whether any cells in steamed areas retained their ability to proliferate after steam treatment; (ii) by testing for dehydrogenase activity in the steamed areas.

Cell division occurred in control Pinto stems when tissues external to the xylem were removed. Extensive proliferation was apparent within 8 days after the tissues had been removed. Cell proliferation disturbed the regular alignment of vascular bundles and forced some bundles outward. The hollow core of the pith became filled with cells as a result of this proliferation. In contrast, microscopic examination of the steamed sections of stems 2 weeks after the steam was applied showed no evidence of cell proliferation, and the central core of the pith remained unfilled.

2,3,5-Triphenyl tetrazolium chloride (TTC) was used to detect dehydrogenase activity (*9*) in steamed regions. Ten pieces of stems from an equal number of plants were cut from areas immediately below the steamed regions and within the same internode. These control samples showed a definite reaction to TTC (development of red color) in less than 1 hour at 32°C in the dark. The color was apparent in 0.2-mm sections of these stem pieces in cells of the epidermis, cortex, phloem, xylem, and pith. In contrast, no color was detected macroscopically in pieces of the steamed regions even after 24 hours in TTC (at 32°C in the dark). In addition, no color was detected microscopically in sections 1 mm or more thick taken from the ten different steamed stems.

From these results it appears that SBMV, or some part of the virus capable of initiating infection, was able to pass from living cells through steamed portions of stems of Pinto bean plants. Subsequently, at least some of these particles moved out of the steamed areas into an environment above the steamed sections that supported virus multiplication. The particles passed through a section of stem in which living cells were not detected.

I. R. SCHNEIDER
J. F. WORLEY
Crops Research Division, Agricultural Research Service, Plant Industry Station, Beltsville, Maryland

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3 December 1957

Effect of Norleucine on the Utilization of D-Leucine by the Rat

Utilization of D-leucine for growth by the rat was recently demonstrated in this laboratory (*1*). This finding is contrary to the experiments of Fierke (*2*) and Rose (*3*). The study described in this report (*4*) was undertaken in an attempt to clarify the apparent discrepancy.

In reading over the experimental procedure used by Fierke (*2*), we noted that a basal diet was used which contained 2 percent of DL-norleucine. There were also described experiments in which it was shown that norleucine is dispensable for the growth of rats, and, moreover, it was found that either of its isomers as well as the racemic form is toxic to them.

In view of these facts it occurred to us that the failure of Fierke and Rose to observe any beneficial effect of D-leucine when it was added to a leucine-free diet was due to the presence of norleucine. The structure of this compound closely resembles that of leucine, and it seems possible that it might act as an antagonist of leucine. If this were true, one would expect a lower utilization of leucine in the presence of norleucine.

This hypothesis was tested in the following way. Sixteen weanling albino rats of the Yale strain were placed on a nitrogen-free diet for a period of 2 weeks. At the end of this protein-depletion period, the animals were divided into four groups of four animals each, which were then fed appropriate diets for 12 days. The composition of the basal diet and the amino acid mixture has been described elsewhere (*1*). The experimental rations included nitrogen-free and leucine-free diets, and the latter diet supplemented with D-leucine alone or with leucine and DL-norleucine.

The results of these experiments are shown in Fig. 1. Protein-depleted rats fed the nitrogen-free and leucine-free diets lost an average of 4 g and 2 g of weight, respectively, during a 12-day experimental period. Diets supplemented with 0.85 percent of D-leucine resulted in an average growth response of 23 g, while the inclusion of 2 percent of DL-norleucine in the same diet resulted in a loss of weight of 1 g. These rats started to gain in weight when the content of D-leucine in the diet was increased.

Growth inhibition, caused by the inclusion of norleucine in the diet, was always accompanied by anorexia and low water consumption. The rats on such a regimen consumed an average of 36 g of food and drank 63 ml of water, whereas those on a similar diet which was devoid of norleucine ate 75 g of food and drank 130 ml of water. Food efficiency (grams of gain per gram of food) and nitrogen efficiency (grams of gain per gram of food nitrogen) were also markedly affected by the addition of norleucine to the diet, as was evidenced from the average figures of −0.03 and −1.0, respectively. The comparable figures for the control group were 0.31 and 16.0. Feeding of higher levels of D-leucine, which brought about the reversal of growth inhibition observed in animals on the former diet, also resulted in an increase in the rats' desire for food and water and a rise in food and nitrogen efficiency ratios.

These experiments confirm our hypothesis—that the inclusion of norleucine in the diet will greatly reduce the utilization of D-leucine by rats. This appears to explain why Fierke and Rose failed to observe any stimulatory effect of D-leucine.

Prior to our study, an antagonism between norleucine and leucine as well as between norleucine and other amino acids had been observed in bacteria (*5*). But the study discussed in the present report is believed to be the first demon-

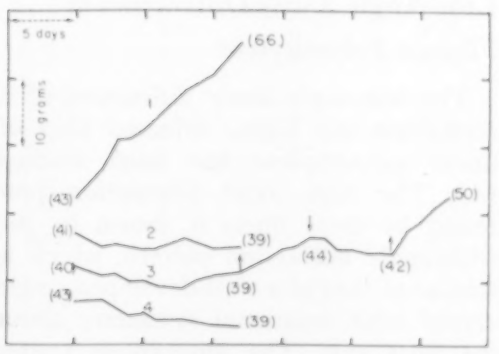

Fig. 1. Average growth response of weanling protein-depleted rats to D-leucine in the presence and absence of norleucine. The numbers in parentheses denote the average initial and final weights of four rats. Curve 1, leucine-free diet plus 0.85 percent D-leucine. Curve 2, leucine-free diet. Curve 3, leucine-free diet plus 0.85 percent D-leucine plus 2 percent DL-norleucine. The two solid arrows pointing to the top of the graph indicate points at which the percentage of D-leucine was increased from 0.85 to 1.60 and 2.20, respectively, while the solid arrow pointing to the bottom of the graph indicates the point at which the dietary level of D-leucine was decreased to that at the beginning of the experiment (0.85 percent). Curve 4, nitrogen-free basal diet.

stration of an antagonism between norleucine and leucine in mammals.

The mechanism of norleucine toxicity and its reversal by leucine cannot be explained at present. The growth inhibition caused by the inclusion of amino acid analogs in the diet has been frequently explained as resulting from the inhibition of protein synthesis; more recently it has been attributed to the formation of "foreign" protein, in which the particular amino acid is replaced by its analog. Indirect evidence for the latter possibility in our system is given by the recent finding that the administration, by intravenous injection, of DL-norleucine-3-C^{14} to cows resulted in the incorporation of this amino acid into casein (*6*). Norleucine does not seem to be a natural constituent of casein or of other proteins that have been investigated to date.

M. RECHCIGL, JR.
J. K. LOOSLI, H. H. WILLIAMS
Departments of Animal Husbandry and *Biochemistry and Nutrition,*
Cornell University, Ithaca, New York

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12 December 1957

Low-Angle X-ray Diffraction of Fibrous Polyethylene

The low-angle x-ray diffraction of a crystalline and highly oriented fiber of linear polyethylene has been studied (*1*). The high axial orientation possessed by these fibers is shown by the wide-angle diffraction pattern, which is similar to that of a well-developed single crystal with rotational symmetry about the fiber axis. The amorphous scatter was weak in this fiber, and the unit cell was verified to be orthorhombic with dimensions identical with those given by Bunn (*2*). Furthermore, the *c* axis—that is, the chain direction—is coincident with the fiber axis. It was also noted that, when a fiber is heated above its melting temperature and then cooled to room temperature, an axial contraction of about 40-fold occurred. This observation is a further indication of the high orientation in the sample. It is doubtful whether the properties of a synthetic macromolecule possessing this degree of axial orientation have been studied heretofore.

The low-angle camera, described elsewhere (*3*) was capable of resolving spacings up to 800 A. The specimen consisted of a fiber bundle of optimum thickness for CuK_α radiation. A well-defined, low-angle pattern, limited to meridional reflections, was observed (Fig. 1). The first-, second-, and fourth-order reflections of a long period corresponding to $d = 410 \pm 20$ A are clearly resolved. A photometry trace showing the resolution between the first two orders is shown in Fig. 2. The second-order reflection is of greater intensity than the first order, and the third-order reflection is missing.

Since equatorial and other non-meridional reflections were absent, experiments were undertaken to determine whether the fiber acted as a one-dimensional diffractor. These experiments involved the tilting of the fiber axis relative to the x-ray beam. Although diffraction persisted with angles of tilt up to 40°, the diffraction orders were poorly defined, thus making any quantitative deductions from these experiments difficult. Nevertheless, one can conclude that this highly oriented polyethylene fiber acts as a one-dimensional diffractor, its reciprocal lattice consisting of discs of large diameter which increase with the order of the diffraction.

Low-angle diffraction patterns have been observed previously in both the fibrous proteins (*4*) and in mechanically oriented synthetic polymers (*5, 6*). The fibrous proteins usually exhibit a series of meridional low-angle reflections, as many as 30 orders having been reported for native collagen (*4*). However, the synthetic fibers previously studied displayed only a single diffuse diffraction maximum corresponding to a much smaller spacing than that reported above. Our observation that several meridional diffraction orders can be obtained from a highly oriented fiber with a principal spacing of 410 A indicates that a well-defined periodicity along the chain direction can also be developed in these substances.

In the case of collagen the low-angle diffraction pattern can be accounted for by a cylindrical band and interband model (*4, 7*). As was suggested by Hess and Kiessig (*5*) a similar interpretation for the periodicity of the fibrous polyethylene can be made. The crystalline regions correspond to the interband and the amorphous regions to the band, with the high orientation causing these regions to approach colinearity. The amorphous regions in polyethylene occur as a consequence of the kinetic difficulties of completely crystallizing a long-chain molecule even though it may be composed of identical repeating units. On the other hand, in the fibrous proteins the chain repeating units (that is, amino acid residues) are not all identical so that a periodicity can also be developed as a consequence of chemical and structural differences along the chain. For synthetic polymers a high degree of orientation must be developed if more than one diffraction maximum is to be observed at low angles.

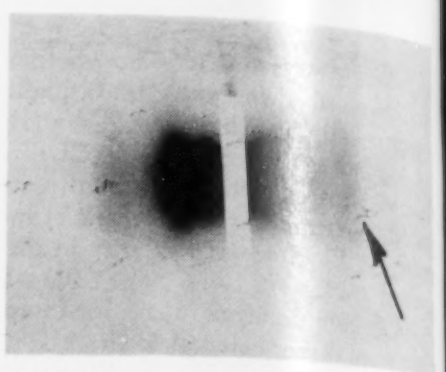

Fig. 1. Low-angle diffraction pattern of polyethylene. Copper K_α, nickel-filtered radiation; specimen-to-film distance, 22.5 cm. The arrow indicates the position of the fourth order of reflection.

Fig. 2. Photometer trace of low-angle pattern of polyethylene (less exposure time than in the example shown in Fig. 1).

LEO MANDELKERN
C. R. WORTHINGTON, A. S. POSNER
National Bureau of Standards, Washington, D.C.

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9 December 1957

Hemagglutination Reaction by the Phosphatide of the Tubercle Bacillus

We have found that, as shown by the hemagglutination reaction in tuberculosis, the phosphatide of the tubercle bacillus possesses an erythrocyte-sensitizing capacity as high as or higher than that of the tuberculin polysaccharide. We have also found that the antigen-antibody system participating in the phosphatide hemagglutination is completely independent of that participating in the polysaccharide hemagglutination.

Of the three phosphatide samples used, the first and the second were isolated from a heat-killed culture of virulent human-type tubercle bacilli, strain Nakano, 8 weeks old on Sauton's medium, according to the method of Boquet and Nègre (*1*) and that of Anderson (*2*). The third sample was isolated according to the former method from a culture of attenuated bovine-type tubercle bacilli, 6 weeks old on the same medium and killed by immersion in acetone. All three samples were purified by treatment with boiling acetone.

In experiments parallel to those with the phosphatide samples, use was made of three samples of tuberculin polysaccharide, prepared according to the conventional method of previous deproteination with trichloroacetic acid followed by precipitation with methanol. The first polysaccaride sample was prepared from an unheated culture filtrate of the strain Nakano, 8 weeks old on Sauton's medium. This is a fraction precipitable at 90 percent methanol, after removal of a fraction precipitable at 30 percent methanol. The second and third samples were likewise isolated from an unheated culture filtrate, of the strain $H_{37}Rv$, of the same age on the same medium. These are fractions precipitable at 80 percent and 95 percent methanol, respectively, after removal of a fraction precipitable at 50 percent methanol. For comparison, use was also made of a sample of old tuberculin prepared from a Sauton culture filtrate of human-type tubercle bacilli, strain Aoyama B.

The nitrogen and phosphorus contents of the antigens (in percentages) were as follows: 0.29 and 2.60 for phosphatide sample 1; 0.15 and 1.97 for phosphatide sample 2; 1.47 and 2.68 for phosphatide sample 3; trace and 0.53 for polysaccharide sample 1; 0.22 and 0.15 for polysaccharide sample 2; and 1.00 and 0.20 for polysaccharide sample 3. The Molisch and orcin-HCl reactions were positive for all the antigens, being slightly stronger for the polysaccharide antigens than for the phosphatide antigens. The biuret, Millon, and xanthoprotein reactions were negative for all the antigens.

Tuberculous sera were obtained from rabbits immunized with the following materials prepared from the tubercle bacillus: (i) whole bacilli killed by immersion in acetone (bacilli BA); (ii) bacilli BA successively exhausted with acetone, methanol, and chloroform (residue RC); (iii) residue RC deprived of its bound lipids by treatment with 1 percent HCl alcohol (residue RHA); (iv) living bovine-type tubercle bacilli; (v) heat-killed bacilli of the strain Aoyama B; (vi) living bacilli of the same strain. The first three materials were prepared from the strain Aoyama B. The exhaustion of the bacilli was carried out at temperatures below 40°C.

Sheep erythrocytes sensitized, according to the conventional method, with the foregoing antigens were brought into contact for hemagglutination with serial dilutions of the sera. The results are summarized in Table 1. As is clearly shown in the table, the three phosphatide antigens are capable of sensitizing sheep erythrocytes to hemagglutination in the presence of tuberculous sera experimentally prepared, and without any previous treatment of the cells. Moreover, it is worthy of notice that, while the erythrocytes sensitized with the polysaccharide antigens and the old tuberculin agglutinated in the presence of the

Table 1. Results of tests for hemagglutination reaction. BA, whole bacilli of the human-type strain Aoyama B killed by immersion in acetone; RC, bacilli BA deprived of its free lipids; RHA, resdiue RC deprived of its bound lipids; Pd. 1, 2, and 3, phosphatide samples; Ps. 1, 2, and 3, tuberculin polysaccharide samples. The numbers under column heads for the various samples indicate the maximum, positive dilutions of the sera.

Serum No.	Sheep erythrocytes sensitized with						
	Pd. 1	Pd. 2	Pd. 3	Ps. 1	Ps. 2	Ps. 3	Old tuberculin
			Bacilli BA				
1	1280	1280	2560	640	–	–	–
2	640	640	640	640	160	160	160
3	5120	2560	5120	640	80	160	–
			Residue RC				
4	–	–	–	640	160	320	320
5	–	–	20	1280	320	640	320
6	–	–	–	1280	640	640	640
			Residue RHA				
7	80	–	80	80	–	–	–
8	–	–	20	40	–	–	–
9	40	–	40	80	–	–	–
			Bovine-type tubercle bacilli (living)				
10	1280	640	1280	1280	640	640	640
11	640	640	1280	1280	640	640	640
12	640	160	1280	1280	640	640	320
			Aoyama B (living)				
14	320	320	320	320	160	160	320
15	320	160	320	640	–	640	160
			Aoyama B (killed)				
16	1280	640	1280	640	320	160	160
17	320	320	640	640	320	320	640
			Control				
19	–	–	–	40	–	–	–
20	–	–	–	20	–	–	–

Table 2. Results of the cross inhibition test with serum No. 10, dilution 160. Results of equal tendencies were obtained with serum No. 14. The numbers indicate the maximum inhibiting dilutions of the inhibiting antigens (1 mg/ml). All symbols are defined in Table 1.

Antigen	Pd.1	Pd. 2	Pd. 3	Old tuberculin	Ps. 1	Ps. 2	Ps. 3
Pd. 1	1024	512	512	–	–	–	–
Pd. 2	1024	128	512	–	–		
Pd. 3	1024	2048	2048	–	–	–	–
Old tuberculin	–	–	–	128	1024		
Ps. 1	–	–	–	–	16	16	18
Ps. 2	–	–			128	32	16
Ps. 3	–	–			512	256	256

sera prepared with residue RC (a residue deprived of its free lipids), the cells sensitized with the phosphatide antigens did not. Besides, as is clearly shown in Table 2, the phosphatide hemagglutination reaction was not at all inhibited by the tuberculin polysaccharides, and vice versa (*3*).

The foregoing two facts clearly indicate that, in the animal body, the formation of antibodies to the bacillary phosphatide takes place independently of the formation of polysaccharide antibodies, at least so far as tuberculin polysaccharide is concerned.

Y. Takahashi
K. Ono

Research Institute for Tuberculosis, Hokkaido University, Sapporo, Japan

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10 December 1957

Pharmacology and Toxicology of Nicotine with Special Reference to Species Variation

During the brief history of modern pharmacology few chemical entities have received such intensive investigation as nicotine. Langley's demonstration (*1*) in 1889 on the ability of nicotine to inhibit transmissions at synaptic junctions initiated a deluge of literally thousands of articles in the scientific literature.

Several researchers have published on the physiological response of animals to nicotine as an index of neural development in the phylogenetic scale. Greenwood (*2*) reported that the toxic effect of nicotine on invertebrate organisms is determined by the degree of development of the nervous system but that vertebrate animals which have enough in common to stand near each other in the phylogenetic order may react differently to nicotine.

Our interest in this alkaloid results from a screening program designed for the selection of a drug to immobilize wild deer for restocking wildlife conservation areas. The subsequent successful capture and translocation of over two hundred wild white-tailed deer (*Odocileus virginianus*), with nicotine administered by the dart-gun technique previously reported (*3*), warrants the reappraisal of reported toxicity of this chemical.

Gause and Smaragdova (*4*) have compared toxicity of synthetic D-nicotine with natural L-nicotine and have postulated that the variance of toxicity between the two isomers is a function of development of spatially specific receptors at the neuroeffector synapse of voluntary muscles, that it is proportionate to the development of the acetylcholine system.

Pharmacologically, nicotine is considered to be an autonomic active drug with curariformic activity. The classical biphasic action, consisting of evanescent stimulation followed by paralysis of all autonomic ganglia, is generally conceded to be a function of dose, with increasing concentrations involving the central nervous system and myoneural junctions.

The ability of nicotine to induce experimental catatonia, similar to the cataleptoid action of bulbocapnine, was demonstrated by Gutierrez-Noriega (*5*). The maintenance of abnormal or bizzare body positions typical of catalepsy was observed in dogs injected with relatively small doses of nicotine tartrate.

Repeated administration of small or sublethal quantities of the alkaloid, or its salts, results in a rapidly diminishing pharmacological response. Ruppert (*6*) reports that isolobinine and nicotine produce mutual tachyphylaxis in rats and that one-tenth of the effective dose for either of these alkaloids will confer protection against convulsive doses; however, tachyphylaxis is less pronounced in cats and rabbits.

Species variation in ability to eliminate nicotine and in susceptibility to toxic effects was reported by Larson *et al.* (*7*). The median lethal dose, by intravenous injection, was established for cats as 2.0 mg/kg; for dogs, as 5.0 mg/kg; for mice, as 7.1 mg/kg; and for rabbits, as 9.4 mg/kg. However, when nicotine was perfused slowly, intravenously, over an 8-hour period, dogs could tolerate 2.0 times the lethal dose, rabbits 3.3 times, mice 4.6 times, and cats, 10.0 times the lethal dose; this indicates that the ability to metabolize or excrete nicotine is independent of species susceptibility.

Aqueous solutions of chemically pure, natural L-nicotine, unbuffered, of *p*H 8.4, or the equivalent amount of nicotine salt, were administered by intramuscular routes, to all experimental animals. Injection of wild or feral animals was accomplished with the projectile type automatic injecting hypodermic syringe, delivered by a 50-caliber pneumatic rifle (*8*). To avoid development of tachyphylaxis, animals were used only once, or were allowed an interval of not less than 48 hours for eliminating all traces of the drug. The end point for determining paralysis of animals was loss of locomotor function.

The minimal paralytic dose of nicotine and the approximate lethal dose for 14 species are listed in Table 1.

After minimal paralytic doses of nicotine an average of 3 minutes is required for development of symptoms of polyuria, locomotor ataxia, lethargy, and catatonia or flaccid paralysis. Large sublethal amounts of nicotine precipitate severe convulsive seizures, followed by flaccid paralysis and recovery within three hours. Death generally occurs during the convulsive seizure from lethal doses of nicotine; however, monkeys and cattle may succumb to latent effects of minimal lethal doses many hours after their recovery from paralytic effects. Necroscopy studies of these animals reveal pronounced urinary retention, distended ureters, and acute hydronephrosis with petechiasis, indicative of acute uremia. In subparalytic doses, nicotine is an effective emetic in those animals capable of emesis and promotes lethargy or somnolence in all species studied.

The paralytic dose of nicotine administered by intramuscular injection and the approximate lethal dose have been established for 14 species of animals (*9*).

The therapeutic index for nicotine is sufficiently great to allow the use of

Table 1. Paralytic and approximate lethal doses of nicotine, administered by intramuscular injection.

Animal	No. of observations	Minimal effective dose (mg/kg)	Approximate lethal dose (mg/kg)	Therapeutic index
Pigeons	20	5.0	9.0	1.8
Mice	100	5.0	8.0	1.6
Rats	50	10.0	15.0	1.5
Rabbits	30	18.0	30.0	1.6
Guinea pigs	15	8.0	15.0	1.8
Chinchillas	18	10.0	18.0	1.8
Dogs	24	4.5	15.0	3.3
Cats	10	3.5	9.0	2.5
Cattle	38	4.5	9.0	2.0
Horses	6	4.0	8.8	2.2
Swine	4	6.6	> 14.0	not determined
Goats	200	3.0	13.0	4.3
Deer	205	3.0	9.0	3.0
Monkeys	8	4.0	6.0	1.5

careful estimates of body weight in calculating paralytic doses to be administered (by means of the projectile hypodermic syringe) for the purpose of safely inactivating wild, feral, or dangerous and unmanageable animals.

S. D. Feurt, J. H. Jenkins, F. A. Hayes, H. A. Crockford
Schools of Pharmacy, Forestry, and *Veterinary Medicine, University of Georgia, Athens,* and *Georgia Game and Fish Commission*

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11 December 1957

Number of Species of Black-Widow Spiders (Theridiidae: Latrodectus)

The last revision of the black-widow genus *Latrodectus* was that of O. P.-Cambridge in 1902 (*1*). Chamberlin and Ivie in 1935 (*2*) made a study of the black-widow spiders north of Mexico, establishing several subspecies names subsequently used by nonarachnologists in this country. Although there is a steady flow of papers on the toxicology and distribution of black-widow spiders, the taxonomists have not kept pace with their colleagues. The common black-widow spider of the United States is now revealed to include two separate species. As a result of this, the specific toxicological properties of the two have been confused consistently in the literature (a further example of the dependence of physiological research upon accurate determination of the experimental animal).

There are two catalogs listing all the species of spiders known. Roewer's *Katalog der Araneae* (*3*) lists 21 species of *Latrodectus*. Bonnet, who covered the arachnological literature to the year 1938 in his *Bibliographia Araneorum* (*4*), also lists 21 species. Since the completion of these works, *Latrodectus rivivensis* Shulov, 1948, has been described, from Palestine.

In my systematic revision of the comb-footed spiders (Theridiidae), in progress for the last 6 years, I have now included the genus *Latrodectus*. The anatomy of all species was studied in some detail, and for the first time the many names created by Dahl (*5*) and Badcock (*6*) could be evaluated.

Although the structure of the genitalia is the usual criterion for separating spider species, some authors (mostly those otherwise unacquainted with spiders) state that genitalia are not useful in differentiating species of *Latrodectus*. My researches indicate that wherever two forms seem to occur in the same locality there are also differences in the genitalia of these two. Coloration and spines, however, are variable characters.

From a study of large series of specimens it can be concluded that there are three species in America: *Latrodectus geometricus* C. L. Koch, 1841, the cosmotropical brown widow; *Latrodectus mactans* (Fabricius, 1775), also limited to the warmer regions and apparently found in all continents; and *Latrodectus curacaviensis* (Müller, 1776) [= *L. bishopi* Kaston, 1938], endemic in America from Argentina to Canada but possibly more common in the temperate zones of North and South America. The last-named species has been confused with *L. mactans*, and much of the *L. "mactans"* literature of the United States may refer to either or both of the species. No conspicuous morphological differences could be found between *L. hasselti* (New Zealand to India), *L. indistinctus* (Africa), *L. tredecimguttatus* (Mediterranean region), and *L. mactans*. It is possible that they all represent one species. *Latrodectus hystrix* Simon, 1890, from Yemen, and *L. pallidus* O. P.-Cambridge, 1872, from Palestine, Asia Minor, and southern Russia, seem to be distinct. All other names in use appear to be synonyms of the names listed above. It is possible, thus, that the 21 nominal species cited in the literature may have to be reduced to five species.

In the males of *L. curacaviensis*, confused with *L. mactans* in this country, the palpal embolus is wider than and about three-quarters as long as the embolus in males of *L. mactans*. The connecting ducts of the female genitalia have three outside coils in dorsal view, while in *L. mactans* there are four or five. The legs of females of the former species are longer, although the coloration and spines are similar. There are differences in habitat: *L. curacaviensis* lives in trees and shrubs, above ground, in Florida; *L. mactans* lives on the ground. In northern states, *L. curacaviensis* lives under logs and stones in woods and fields and probably gets into urban surroundings only rarely, while *L. mactans* is usually found in trash and near dwellings. The northernmost localities where *L. mactans* is found are Maryland, Indiana, Wyoming, Utah, and central California, although this species may be found also in houses in the larger northern cities. The common black-widow spider of New England, most northern states, and, probably, southern Canada is *L. curacaviensis*.

Latrodectus geometricus has only occasionally been found in this country, in cities of Florida. The females are usually gray in color. The palpal embolus is narrower and about one-quarter longer than that of *L. mactans* (*7*).

Herbert W. Levi
Museum of Comparative Zoölogy, Harvard University, Cambridge, Massachusetts

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15 January 1958

New Absorption Peak of Tyrosine

While we were investigating the possible adaptation of the Holiday (*1*) method for the determination of small amounts of tyrosine in sea water, we observed a hitherto unreported absorption peak of tyrosine. This peak, at 330 mμ, arose when dilute solutions of tyrosine (1 to 100 mg/lit) in artificial sea water were autoclaved at relatively high pressures (70 to 90 lb/in.^{2}) in the presence of alkali concentrations ranging from 0.12 to 5.0*N* (Fig. 1, curves 1 and 2).

A similar peak, displaced 10 mμ toward the ultraviolet, was found when tyrosine solutions were autoclaved either in artificial sea water or in distilled water alone. Tryamine, 3,5-diiodotyrosine, and *p*-hydroxybenzoic acid behaved similarly (Fig. 1, curves 3, 5, 7), while other amino acids tested, including phenylalanine, proline, hydroxyproline, histidine, and tryptophan showed no such spectral change. Both crystalline albumin and plasma albumin solutions produced the

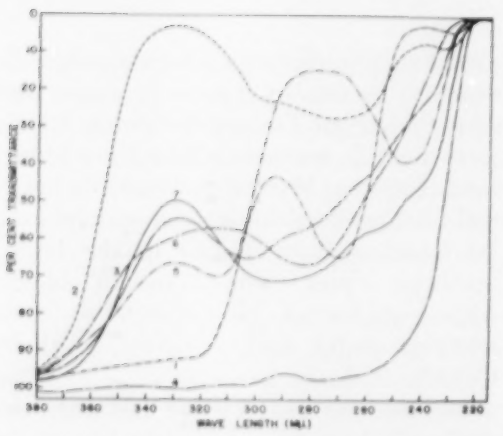

Fig. 1. Absorption peaks of tyrosine: (curve 1) 0.01 g of tyrosine per liter in 0.175*N* NaOH autoclaved 3 hours at 80 lb/in.^{2}; (curve 2) 0.01 g of tyrosine per liter in 0.175*N* NaOH; (curve 3) 3,5-diiodotyrosine in 0.125*N* NaOH autoclaved 4 hours at 80 lb/in.^{2}; (curve 4) plasma albumin in 0.125*N* NaOH; (curve 5) *p*-hydroxybenzoic acid in 0.125*N* NaOH autoclaved 4 hours at 80 lb/in.^{2}; (curve 6) plasma albumin in 0.125*N* NaOH autoclaved 3 hours at 80 lb/in.^{2}; (curve 7) tyramine in 0.125*N* NaOH autoclaved 4 hours at 80 lb/in.^{2}

same peak at 330 mμ following autoclaving with alkali (Fig. 1, curves 4 and 6); this is evidently due to the tyrosine content of the protein. The spectral evidence would indicate a structural change, perhaps to an *o*-quinoid structure, common to all the molecules mentioned above, rather than a conversion of the tyrosine to *p*-hydroxybenzoic acid (*2*).

ZOULA P. ZEIN-ELDIN
BILLIE Z. MAY
U.S. Fish and Wildlife Service, Galveston, Texas

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8 July 1957

Effects of Handling and Eating on Plasma Electrolytes

Variations in the concentrations of plasma potassium and sodium in mammalian venous blood have been principally investigated in studies of response to the administration of chemical agents or to the application of severe stressor agents. The present report (*1*) describes fluctuations in concentrations of plasma potassium and sodium in the goat which were found to occur after the handling necessary to bring the well-trained animal into the laboratory and during the eating of a greatly desired food. In addition, hematocrit value and plasma glucose concentration were measured under the same conditions, since changes in these physiological variables may help to clarify the mechanisms affecting concurrent changes in plasma potassium and sodium concentrations.

Four dioestral female and two male goats, from 2 to 2½ years of age, served as subjects. In preparing these animals for previous experiments, each animal had been handled by laboratory personnel on from 30 to 50 days. Three weeks before the experiment described in this report, the subjects were quartered by pairs in rooms in the laboratory building, where they were not disturbed except for evening feeding. Water, a legume hay, and grain (G.L.F., 18% Dairy) were continuously available ad libitum. During this time, three of the animals were subjected to five sham experimental sessions in which no blood samples were taken. The remaining three animals had recently been subjects in a study very similar to that reported here and were thus already familiar with the experimental procedure. In their living quarters the animals would neither approach an experimenter voluntarily nor allow an experimenter to approach without showing some sign of flight. However, once leashed, the animals led easily and showed no overt sign of fear of the experimenter. A few days before the experiment began, a polyethylene catheter was inserted into the external jugular of each animal and held in place with collodion for the duration of the experiment. From the first day of the experiment, the animals received restricted quantities of grain, randomly varying daily from zero to 1 qt per animal. Water and hay intake remained unrestricted.

The experimental sessions took place in the morning, and each session lasted about 3 hours. The experimenter entered the living quarters, leashed an animal, and led it down a 25-ft hallway to the experimental room. There the animal leaped onto a platform, and a strap passing through a wall ring was fastened around the abdomen. This initial stress to the animal lasted about 2 to 3 minutes and constitutes what is here referred to as "handling." The experimenter then withdrew to an adjoining room within view of the subject, approaching only to draw blood samples, painlessly, by means of the previously prepared catheter. After about 1½ hours, a pail full of grain was fastened to the platform and the subject was allowed to eat until obviously satiated—a period of from 10 to 30 minutes. All subjects showed signs of excitement and attempted to walk off the platform towards the experimenter when he entered carrying the pail, and all subjects ate as soon as the pail was sufficiently near. The experimenter then approached only to draw further samples, and the session was ended about 1½ hours after the presentation of food. Each subject was subjected to four experimental sessions, at least two of which were on successive days.

A total of 10 to 15 samples, of 5 ml each, were obtained during each experimental session (*2*). The report presents analyses of the samples obtained within 2 to 5, 15 to 25, 35 to 45, 55 to 65, and 75 to 85 minutes after the experimenter entered the animals' living quarters and of the samples obtained within the same time intervals after the presentation of grain—a total of 240 samples.

Each sample was withdrawn into a syringe containing about 0.01 mg of heparin and was immediately transferred to a 15-ml graduated tube and centrifuged for 5 minutes at 3000 rev/min in an International clinical centrifuge. The hematocrit reading was then made from the centrifuge tube, and the samples were centrifuged for an additional 10 minutes before further analyses were made. Plasma potassium and sodium concentrations were determined by the lithium internal standard method with the flame photometer (Perkin-Elmer, model 52C).

The mean data for all animals are plotted for each physiological measure in Fig. 1. The data for each of the six curves were treated independently in an analysis of the significance of linear and nonlinear regression components, by means of the method of orthogonal polynomials (*3*). Quadratic regression—that is, one point of inflexion—is significantly present beyond the 1.5-percent confidence level in five of the curves. However, only linear regression is significant for the hematocrit data obtained after eating.

It is evident from Fig. 1 that a rapid

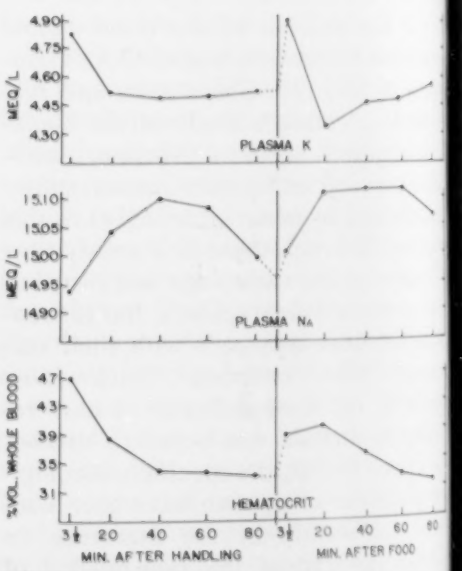

Fig. 1. Mean concentrations of plasma potassium (K) and sodium (Na) and hematocrit values for six animals as a function of time after the onset of handling, and of time after presentation of food. The central ordinate represents the time when food was presented, and the dotted lines represent linear extensions of the curves in the period between the last sample obtained before the presentation of food and the first sample obtained after the presentation of food.

rise in plasma potassium and hematocrit value occurred after the presentation of food. The significance of these rises was tested by pairing the mean value obtained for each subject within the last interval before, and the first interval after, the presentation of food. A t value of 5.32 was obtained for the differences between the paired hematocrit values, and a t of 4.34 was obtained for the potassium values. Each t is associated with 5 degrees of freedom, and both exceed the value necessary for significance at the 1 percent level.

The curve for plasma potassium obtained after handling, and its similarity to that obtained after the presentation of food, suggests that a rapid rise in plasma potassium concentration may have occurred within 2 minutes after the onset of handling. However, no samples were obtained in this interval, and direct evidence for this view is not presented here. In the case of hematocrit value, there is much evidence in the literature that a rise in hematocrit value occurs within 1 to 2 minutes after introduction of a variety of stimuli (*4*). It is therefore probable that, after handling, such a rise occurred before the fall shown in Fig. 1.

The initial rise in plasma potassium after the presentation of food is followed within 20 minutes by a marked, rapid fall below the prefood level and is then followed by a slow rise to prefood levels. The initial rise in hematocrit value is followed by a slow decline, which levels off in 60 to 80 minutes.

Plasma sodium concentration rises slowly after both handling and eating, reaches a peak within 20 to 60 minutes, and then slowly declines.

In a further study, plasma glucose concentration was followed in four of the animals in an experimental session similar to that described above. However, food was presented to the animals 30 minutes after the onset of handling, and samples were obtained at ½, 12, and 25 minutes after handling commenced and at 5, 15, and 25 minutes after the presentation of food. Plasma glucose determinations were made by the Somogyi-Shaffer-Hartmann titration method (*5*). No systematic changes in plasma glucose concentration were found to occur during the experimental sessions, and the mean of the variations which did occur was within the error of the method—that is, between 2 to 3 mg percent.

The variations in plasma potassium concentration that were found, in this study, to follow handling and eating in the well-trained goat are similar to previous results obtained after administration of adrenaline in other species (*6*). However, the lack of change in plasma glucose concentration following handling and eating suggested that effective quantities of circulating adrenaline are not present under these conditions. To obtain more evidence for this hypothesis, blood samples were taken from four of the catheterized animals at 5, 15, and 25 minutes before, and at the same times after, intracatheter injections of adrenaline chloride (*7*). It was found that, although injection of 50 μg of adrenaline produced an average peak increase in hematocrit value of 17 percent, (approximately the same increase as the average rise previously found following eating), it also produced a concurrent average peak rise of 24.4 percent in plasma glucose concentration.

Thus, although variations in concentrations of plasma potassium and sodium are found after handling and eating in the well-trained goat, these changes apparently are not mediated by the release of adrenaline. The occurrence of significant variations after handling and eating also suggests that suitable controls for these effects may be necessary in studies of blood electrolytes in vivo.

JAMES D. BLOCK*
Cornell Behavior Farm Laboratory, Cornell University, Ithaca, New York

References and Notes

1. These studies were conducted during the tenure of a research fellowship of the Social Science Research Center of Cornell University, and of a research fellowship of the U.S. Public Health Service.
2. F. Courtice [*J. Physiol.* (*London*) **102**, 290 (1943)] estimates the blood-volume–weight relationship in the goat to be about 70 ml/kg. On the basis of this estimate, the blood loss per animal during an experimental session was calculated to range from 1.5 to 2.0 percent of total blood volume.
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* Present address: Department of Psychiatry, Albert Einstein College of Medicine, New York, New York.

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Early Sexual Maturity in the Female Short-Tailed Weasel

Delayed implantation in some of the Mustelidae has long been recognized (*1*). The age at which females first breed is not so well known. The female stoat (*Mustela erminea*) is said to first come into oestrous and ovulate spontaneously in May or June, before it is fully grown. Further ovulations take place at intervals of not less than a month before the next spring, when the animals become pregnant for the first time. Many first-year females mate at oestrous, but matings prove sterile outside of the limited breeding season (*2*). Young females of *Mustela frenata* mate when they are 3 or 4 months old, so that all females of this species may produce young in the spring, when they are about 1 year old (*3*).

Fig. 1. Blastocysts of *Mustela erminea cicognanii*. The vesicles are partially collapsed but are as near perfect as one usually recovers in fresh animals. The inner cell mass in both embryos is slightly depressed (× 52).

A female *Mustela erminea cicognanii* taken at Ithaca, New York, on 22 July 1956 was a young of the year. The skull and skeletal characters of this specimen, compared with those of young of known age, testify to its immaturity (*4*). Seven blastocysts were flushed from the uterine horns (Fig. 1). These, only slightly collapsed, measured 400 to 750 μ in diameter. The circular inner cell mass has a diameter approximately one-third that of the embryo. The hand-sectioned ovaries show well-developed corpora lutea. Although the female of this species may mate when it is 3 months old (possibly less), males do not become sexually mature until the late winter or early spring of their second year. This is the first positive evidence that the female short-tailed weasel may have a productive mating in its first summer.

W. J. HAMILTON, JR.
Department of Conservation, Cornell University, Ithaca, New York

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National Academy of Sciences

Abstracts of papers presented at the
Annual Meeting, 28–30 April 1958, Washington, D.C.

Examination of Human Erythrocyte Populations for Somatic Mutation at the ABO Locus

In view of the size of the human erythropoietic system, its stem-line mode of propagation, and the normal range of mutation rates, it seems inevitable that a heterogeneity resulting from somatic mutation should be detectable in the peripheral blood. This has in fact been found in the form of a small proportion of exceptional erythrocytes lacking A antigen in normal AB and in heterozygous A individuals. The proportion of such cells was determined by an isotope dilution method involving successive agglutinations of Cr^{51}-labeled cells with excess carrier (unlabeled) cells. At age about 35, the proportion is about 0.001, indicating a mutation rate of about 3×10^{-9} per hour. The cells were isolated from AB bloods in quantities sufficient for phenotypic characterization. They show a great increase in H substance, are fully agglutinated by anti-B, and sometimes show partial agglutination with anti-A reagents other than the one used in the isolation procedure. A mutational origin is not proved, but the results are highly suggestive.

K. C. Atwood, S. Scheinberg
Oak Ridge National Laboratory

Changes in the Sun's Polar Magnetic Field

The existence of a primary dipolar magnetic field of the sun was shown by the magnetograph in 1952. This field, with effective intensity of about 1 gauss, was limited to high latitudes, above $\pm 55°$. As reported by Babcock and Babcock in 1955, the polarity was positive in the North, and negative in the South, opposite to that of the earth's magnetic field. The sun's poloidal field is, in the mean, symmetric about the axis of rotation but shows random fine structure and marginal irregularity.

Observations of solar magnetic fields have been continued in Pasadena and, since May 1957, also on Mount Wilson. Through 1955 and 1956, the preceding description of the polar fields is confirmed. By June 1957, the intensity had irregularly decreased, and the field at the South Pole had reversed its polarity. Since then the field near the South Pole has been dominantly positive and stronger than the field near the north heliographic pole, which shows the same magnetic polarity. Results from both magnetographs are accordant, and the combined mean intensities for latitudes greater than $\pm 50°$ are: North Pole, + 0.2 gauss; South Pole, + 0.6 gauss.

This significant change of intensity at both poles, and reversal of polarity at the South Pole, is delayed in phase some 3 years with respect to the minimum in the frequency of sunspots. The variations of the sun's poloidal field probably reflect large-scale patterns of circulation related to the 22-year solar magnetic cycle; they are presumably closely related to various solar-terrestrial phenomena.

Harold D. Babcock
William C. Livingston
Mount Wilson and Palomar Observatories

Ionic Fission of the O-O Bond in t-Butyl Persulfonates

t-Butyl benzenepersulfonate, a new class of perester, and four para-substitution products have been prepared. These decompose quantitatively in methanol to give acetone and arylsulfonic acid by ionic cleavage of the peroxide bond. Kinetic studies of the decomposition of *t*-butyl pertosylate in methanol and aqueous methanol have been carried out. The reaction is subject to unusual salt effects, which show pronounced maxima with salt concentration and which disappear almost completely with the addition of water to the methanol. In contrast to 9-decalyl perbenzoate, *t*-butyl pertosylate shows strong negative deviation from the Grunwald-Winstein equation [E. Grunwald and S. Winstein, *J. Am. Chem. Soc.* **70**, 846 (1948)] near the methanol end of a series of methanol-water mixtures, but obeys this equation over the rest of the range. A mechanistic interpretation of this behavior is offered.

Paul D. Bartlett, Bayard T. Storey
Harvard University

Bioelectric Phenomena in Hydrodictyon africanum

Hydrodictyon patenaeforme was the subject of sap analysis some years ago; potassium accumulation was 4000-fold the external concentration. Bioelectric measurements were made during the past year with *H. africanum*; this species has spherical cells up to 3 or 4 mm in diameter. They can be impaled upon microcapillary salt bridges and live for about a day, yielding large bioelectric potentials and supplying appreciable current. A potential difference (P.D.) of 50 to 60 mv (outside positive) was found when the cells were bathed in tap water or culture solution. This value was increased to 100 mv when the cells were exposed to flowing distilled water. Salts lower this value, KCl being about 3 times as effective as NaCl in this regard. The relative mobility of K^+ in the protoplasmic surface is about 5, if Cl^- is taken as unity.

The resistance of intact cells to direct current was about 100,000 ohms, when the cells were washed with distilled water; allowing for leakage along the cellulose wall, protoplasmic values of 10,000 ohms/cm² of cell surface were calculated. Very high current densities lowered this value, but no stimulation phenomena could be evoked, either anodally or cathodally.

Both potential and resistance were sensitive to light, the effect being greatest in distilled water. Illumination (100 ft-ca) raised the P.D. by 10 or 15 mv and lowered the resistance; darkening lowered the P.D. in a characteristic time course, accompanied by a twofold increase of resistance for several minutes. These light effects were greatly decreased by salts (especially by KCl)—along with the P.D. itself.

Low oxygen tension in the medium lowered the P.D. by about 50 percent with prompt recovery in the light. There were no special effects of NH_3 (as in *Halicystis*), either alone or in combination with light. The temperature coefficient of the P.D. is very low.

L. R. Blinks
Hopkins Marine Station

Behavior of Calcium Carbonate

Anomalies in the chemical, mineralogical, and biological behavior of calcium carbonate diminish when they are viewed concurrently. Best values for the apparent solubility product constant K'_{CaCO_3} in sea water are consistent mineralogically. At salinity 36‰ and T 30°C, K' aragonite is 0.99×10^{-6} and K' calcite 0.53×10^{-6}. Free energy difference indicated is −370 cal/mole, compared with recent experimental values of −270 to −334.

Slope relations of salinity ratios for the empirical product $Ca^{++} \times CO_3^{--}$ and for provisional activity products confirm the thermodynamic significance of the empirical parameter K'_{CaCO_3}. Very high supersaturation in $CaCO_3$ implied for warm ocean waters by K' values suggests complexing of some analytical calcium, inhibiting combination with CO_3^{--}.

Experimental precipitation of $CaCO_3$ from solutions and sea water indicates that mineral structure depends on degree of saturation, not on impurity content or on temperature alone. Aragonite precipitates from solutions supersaturated for

both calcite and aragonite; calcite precipitates between saturation levels for the two species. Hypersaline sea water west of Andros Island, Bahamas, yields aragonite with O^{18}/O^{16} and C^{13}/C^{12} ratios indicating precipitation mainly during the warmer months. Calcite is the usual precipitate from fresh waters, except where high supersaturation results from slow diffusion, high evaporation, or biologic intervention. Variations in scleroprotein suites of calcite and aragonite layers in shells imply distinct chemical regimens.

Metastable aragonite persists in contact with supersaturated solutions. Inversion to thermodynamically stable calcite follows transfer to solutions undersaturated for aragonite or to the atmosphere. Retarded inversion of dry aragonite may reflect primary concentration in the crystal structure of isomorphous cations. These implications are consistent with geologic evidence.

PRESTON E. CLOUD, JR.
U.S. Geological Survey

Dose-Effect Relationships for X-ray Induction of Mutations in Three Genes of Escherichia coli

By means of a technique developed during the past few years, it is possible to measure reverse mutability in individual genes that control the biosynthesis of essential compounds (reversions from auxotrophy to prototrophy), even though the rate is extremely low. The limit of sensitivity for detection of the reverse mutants is about 10^{-11}. We are studying dose-effect relations in several auxotrophs of *Escherichia coli* by using low doses of x-rays. Results obtained with three mutants, arginine-3 (*ar-3*), methionine-2 (*me-2*), and threonine-1 (*thre-1*), are presented here. It has been determined that the spontaneous mutation rates per 10^{10} bacteria are 10.8 in *ar-3*, 15.6 in *me-2*, and 2.3 in *thre-1*, and that the doubling doses are 68 r for *ar-3*, 186 r for *me-2*, and 85 r for *thre-1*. The lowest dose used in experiments was 8.5 r with *ar-3* and 17 r with the other two; and the highest dose was 4320 r. The data show a linear dose-effect relationship for these three genes. Thus, within the limits of the experiments, no threshold was detected. The results also indicate that natural radiation could account for only a small fraction of the spontaneously occurring mutations.

M. DEMEREC
Carnegie Institution of Washington, Cold Spring Harbor

JOAN SAMS
Biological Laboratory, Cold Spring Harbor

Interaction Properties of Sonically Fragmented Collagen Macromolecules

From viscosity and optical rotation measurements Doty and Nishihara suggested that sonic irradiation of acid solutions of soluble collagen (tropocollagen or TC) fragments the macromolecules without appreciable denaturation—that is, uncoiling of the triple helix structure. We have verified this supposition by application of well-established methods for testing the specificity of macromolecular interaction. This involves electron microscopic examination of the aggregation patterns produced under various conditions. Sonic irradiation rapidly destroys the ability of TC to reconstitute the native type fibrils (having a band pattern with 700 A axial repeat). However, such irradiated macromolecules can still form the "segment long-spacing" (SLS) type aggregates having lengths and band patterns indistinguishable from those obtained from untreated preparations. Dimeric and polymeric SLS structures, only rarely encountered in untreated material, are commonly found. With longer irradiation the transverse fragmentation of the TC macromolecules becomes more extensive, judging from the lengths of the SLS structures observed. With longer irradiation transverse fragmentation of the TC macromolecules occurs. Analysis of the band patterns of aggregates of SLS formed from these fragments indicates that rupture occurs at well-defined regions of the macromolecules.

These results not only demonstrate directly the nonrandom nature of the fragmentation but draw attention to the importance of the end regions of the macromolecules in the formation of the various possible aggregation types, normal and abnormal.

ALAN J. HODGE, FRANCIS O. SCHMITT
Massachusetts Institute of Technology

Role of Extracellular Enzymes in the Pathogenesis of Dutch Elm Disease

Cellulase and polygalacturonase are produced extracellularly by the Dutch elm disease pathogen, which lives in water-conducting tubes of the xylem and induces symptoms of water deficiency. The cellulase does not attack cellulose from elm wood, cotton, or filter paper but rapidly hydrolyzes carboxymethylcellulose to glucose. The pectic enzyme hydrolyzes sodium polypectate to galacturonic acid, the dimer and trimer of galacturonic acid being the principal products. Neither the cellulase nor the polygalacturonase produces signs of water shortage when introduced into elm cuttings. Impeded water flow in diseased trees has been ascribed to increased viscosity of water or mechanical obstructions. Enzymes are said to raise the viscosity of water in the stem by partially hydrolyzing cell-wall materials. This cannot be so in Dutch elm disease because of the inability of the cellulase to attack the native cellulose of the cell wall, the inability of the simple hydrolytic products resulting from the action of these enzymes to raise the viscosity of water, and the observation that viscosity of tracheal fluid in diseased stems is that of water itself. Ballooning of the pectic middle lamellae into water-transporting vessels to form tyloses occurs in diseased trees too infrequently to impede water flow significantly. However, polygalacturonase might dislodge tyloses by weakening the point of attachment. Thus, several could move in the transpiration stream to form a dam at a narrow orifice. The main function of the enzymes is probably to digest cell-wall materials, thus aiding the fungus in obtaining its food supply.

A. E. DIMOND, AKHTAR HUSAIN
Connecticut Agricultural Experiment Station

Wall Thickening in Sieve Elements and Concepts of Translocation

The present study continues the survey of the structural features of sieve elements, specialized cells generally assumed to be the main conduits through which materials move vertically in the phloem tissue of plants. The mature and, presumably, conducting sieve elements show a wide range of variation in thickness of walls.

Some species have rather thin homogeneous walls, others have a distinct inner thickening which varies from a barely perceptible layer to one that almost occludes the lumen of the cell. Since thick-walled sieve elements occur in many species—one third of approximately 150 species examined in this study had the special wall thickening—this character is not unusual and must be taken into account in formulating concepts of translocation. The presence of thick walls weakens support for the pressure-flow hypothesis; it puts less strain on certain diffusion hypotheses. Whether extensive or not, the thickening never develops over the various sieve areas. This feature strengthens the usual assumption that sieve areas play an important role in translocation through the sieve elements.

KATHERINE ESAU
VERNON I. CHEADLE
University of California, Davis

Yield of Photosynthesis from Simultaneous Illumination with Pairs of Wavelengths

In general, the yield of photosynthesis from suspensions of algal cells illuminated with two wavelengths of light given simultaneously is not greater than the sum of the yields for the same two wavelengths given individually. We found this to be true for a number of pairs of wavelengths (for example, 546 and 468 mμ, 436 and 644 mμ, and 578 and 480 mμ). Warburg [*Angew. Chem.* **69**, 627 (1957)] reported that the yield for light of 546 mμ was substantially increased by simultaneous illumination with light of about 460 mμ. Although we made measurements with light of 546 and 468 mμ under a considerable range of conditions (including those specified by Warburg), we found no evidence of increased yield from the combination of these two wavelengths. We tested various combinations of intensities and exposures for periods ranging from minutes to hours. We tried both

Table 1. Increase in yield of photosynthesis from a band of long-wave red light.

Wavelength of supplementary light	Increase in yield (%)	
(mμ)	*Chlorella*	*Porphyridium*
644	28	0
578	19	15
546	12	100
508	5	85
480	60	0
468	40	
436	10	0
405	5	
365	7	0

dense and thin suspensions of cells, in alkaline carbonate buffer and in acid culture medium, with carbon dioxide concentrations ranging from 0.5 to 9 percent, at temperatures of 5° and 20°C.

On the other hand, as we reported a year ago [*Science* 125, 746 (1957)], the yield of photosynthesis from a band of wavelengths longer than about 685 mμ can be substantially increased by simultaneous illumination with light of shorter wavelengths. We have improved our methods of comparing the effects of different wavelengths of supplementary light, and we have tested additional wavelengths. Table 1 shows the percentage increase in yield of photosynthesis from a band of red light (690 mμ and longer), brought about by supplementing the long-wave red with light of shorter wavelengths. At each wavelength the increase was measured for two intensities of the supplementary light, and interpolation was used to estimate the increase for an intensity of supplementary light which, by itself, would sustain a standard rate of photosynthesis.

For *Porphyridium*, the increases in yield from long-wave red brought about by different wavelengths of supplementary light correspond approximately with the absorption spectrum of phycoerythrin. For *Chlorella*, the dependence of action on wavelength shows a rough correspondence with the absorption spectrum of chlorophyll *b*. For both algae, the results suggest that excitation of chlorophyll *a* alone may be insufficient to sustain maximum efficiency of photosynthesis and that pigments having absorption bands at wavelengths shorter than the red maximum of chlorophyll *a* may play some essential part in photosynthesis.

Collaboration of Ruth Chalmers in the experimental work and support from the National Science Foundation (grant G-1398) are gratefully acknowledged.

ROBERT EMERSON
University of Illinois

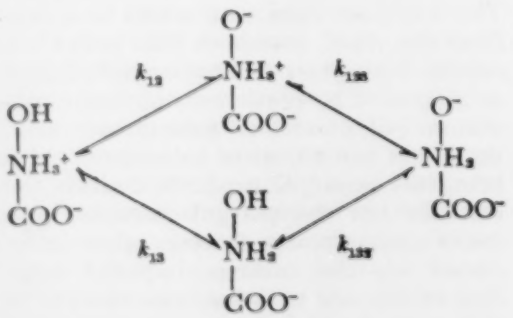
Tetrapod Extinctions at the End of the Triassic Period

The extinctions of various tetrapods (particularly the dinosaurs) at the end of the Cretaceous period are justly famous in geological and biological literature. At the end of the Triassic period several evolutionary lines of tetrapods died out, and although these extinctions were not as extensive as those of the Cretaceous, they were nevertheless significant. The Triassic extinctions, which involved on the whole about half as many known taxonomic units as did the Cretaceous extinctions, evidently indicate a profound change in the history of tetrapod life, probably influenced by changes in environmental conditions. Moreover, the Triassic extinctions caused the disappearance of several lines of tetrapod evolution which had been successful during late Paleozoic and early Mesozoic times. These evolutionary lines were replaced ecologically during middle and late Mesozoic times for the most part by other lines of reptilian evolution, whereas by contrast the tetrapods that became extinct at the end of the Cretaceous period were ecologically replaced for the most part by mammals and birds. Perhaps the changes that distinguish the later Mesozoic vertebrate faunas from those of the Triassic period may be correlated with changes from rather high continental masses and varied environments to low lands and the beginning of a long span of environmental uniformity that was to characterize earth history for many millions of years.

EDWIN H. COLBERT
American Museum of Natural History

Ionization of Individual Groups in Dibasic Acids, with Application to the Amino and Hydroxyl Groups of Tyrosine

In acids containing two groups ionizing in the same *p*H range, it is often possible to follow the state of ionization of a single group by spectroscopic measurements. Thus tyrosine in alkaline solutions, with the carboxyl group ionized, contains four different microscopic forms, interrelated as follows:



The fraction (α_{OH}) of all phenolic groups which are ionized can be obtained from ultraviolet absorption at 2950 to 3050 A. It is readily expressed in terms of the dissociation constants indicated above and the hydrogen ion activity (H^+). More useful, however, is the function:

$$M \equiv \frac{(H^+)\alpha_{OH}}{1-\alpha_{OH}} = \frac{k_{12}(H^+) + k_{13}k_{132}}{(H^+) + k_{13}} \qquad (1)$$

It is seen that, as $\alpha_{OH} \rightarrow 0$, and (H^+) becomes very large, M approaches k_{12} as a limit; as $\alpha_{OH} \rightarrow 1$, and $(H^+) \rightarrow 0$, M approches k_{132}. A plot of log M as a function of α_{OH} thus yields these two constants by extrapolation and also gives k_{13} from the form of the curve in the middle region; k_{123} is automatically determined from the other constants. The experimental curves for tyrosine fit Eq. 1 very satisfactorily; values at 25°C and $\Gamma/2 = 0.1$ are $pk_{12} = 9.63$, $pk_{13} = 9.27$, $pk_{123} = 9.65$, $pk_{132} = 10.05$. These can be checked independently by comparison with overall titrations of tyrosine and O-methyl tyrosine. Equation 1 also gives a good fit to the data of Benesch and Benesch for cysteine. The extension of the method to more complicated cases will be discussed.

JOHN T. EDSALL
R. BRUCE MARTIN
BARBARA R. HOLLINGWORTH
Harvard University

Steroid Hormones as Coenzymes of Hydrogen Transfer

Previous experiments [*Proc. Natl. Acad. Sci. U.S.* 44, 15 (1958)] demonstrated that certain steroid hormones in minute amounts may mediate an enzymatic transfer of hydrogen between di- and triphosphopyridine nucleotides (DPN and TPN).

The following evidence speaks for the identity of the estradiol-17β-dependent soluble transhydrogenase of human placenta with the estradiol-17β hydroxysteroid dehydrogenase of the same source which reacts with both DPN and TPN: (i) The two enzymatic activities are not separated by fractionation procedures which result in purification of more than 100-fold. (ii) No differential inhibition of the two activities could be obtained. (iii) Only those steroids which can undergo enzymatic oxidation will act as coenzymes for transhydrogenation. (iv) The specificity and affinity for natural pyridine nucleotides and synthetic analogs thereof is the same for both reactions.

The reaction velocities observed in the dehydrogenase assay with substrate amounts of estradiol-17β are in each case commensurate with the corresponding rates of transhydrogenation promoted by catalytic quantities of the hormone. In both reactions the 3-acetylpyridine and the 3-pyridinealdehyde analogs of DPN may replace one of the natural nucleotides, whereas desamino DPN is inactive. The affinity of the enzyme for TPN(H) is much higher than for DPN(H), and there is competition between the nucleotides which indicates a single binding site. The relationship of the extent of binding of different pyridine nucleotides to the direction of hydrogen flow in the transhydrogenase reaction will be considered.

The ability of steroid hormones to act as coenzymes for hydrogen transfer between pyridine nucleotides in the presence of mammalian hydroxysteroid dehydrogenases with dual nucleotide specificity will be discussed in relationship to the physiological actions of these hormones and to the specificity of their interaction with these activating proteins.

P. TALALAY, B. HURLOCK
H. G. WILLIAMS-ASHMAN
University of Chicago

Surface of Given Space-Curve Boundary

Let s be a curve in Euclidean three-space, infinity being regarded as a single point. For convenience, the space will be homeomorphic by a mapping I to one with ∞ invariant and s a circle. We define a surface of boundary s as a set S which is compact and connected and (i) outside a toroidal neighborhood of s is a regular surface (that is, adequate for applications of Green's theorem) composed of a finite number of regular elements, such that no two have in common more than an edge or vertex, (ii) every one-cycle of odd linkage with s cuts S, (iii) no open portion of S may be omitted without vitiating (ii).

Thus S may have nodal lines and vertices and need not be orientable. The main facts are the following. If E is a compact set satisfying I, (i), (ii), (iii), it contains s, occludes no points from ∞, is connected and is a surface of boundary s (Proof of connectedness involves Alexander's duality theorem). If E is compact, with I, (i), (ii), it contains a subset which is an S. If S_1 and S_2 are nonidentical surfaces of boundary s there exists a bounded domain with boundary in $S_1 + S_2$. If S_1 and S_2 are surfaces of simply linked boundaries s_1, s_2 respectively, S_1 and S_2 intersect.

Surfaces S_1, as above described, may be used as cut surfaces with branch curves s_1, for multiply valued functions.

G. C. Evans
University of California, Berkeley

Optical Activity Due to Intramolecular Overcrowding

The synthesis of hexahelicene (I)

I

completes one phase of the study of molecules which owe their asymmetry to intramolecular overcrowding. The problems involved in the synthesis and theoretical aspects of the study of compounds which owe their optical asymmetry to intramolecular overcrowding will be reviewed, and future problems will be briefly outlined.

Melvin S. Newman
Ohio State University

The Dependence of Longevity of Human Beings on Body Weight

A discussion of the treatment of statistical information about longevity that seems to have some novel features will be presented. For a factor such as radiation exposure or cigarette smoking, which may decrease longevity even for small values of the parameter, an expansion in a power series including the linear term may be proper. However, the dependence on body weight needs to be discussed in a different way. Both obesity and emaciation decrease life expectancy. There is accordingly an optimal value of body weight that maximizes the longevity, and a power-series expansion in a parameter equal to the difference between body weight and this optimal value will have no linear term. It is found in fact that the statistical information about decrease in longevity in relation to obesity can be satisfactorily expressed by a single term, involving the square of the amount of obesity. Some consequences of this discussion will be presented.

Linus Pauling
California Institute of Technology

Broken Bottlenecks and the Future of Molecular Quantum Mechanics

In the early gold-rush days of quantum mechanics, the effort of theoretical physicists was largely concentrated in applying the new theory to the problem of the basic structure of atoms, molecules, solids, and liquids. Great advances were made, but quantitative progress toward understanding the electronic structure of extranuclear matter was frustrated for all but the simplest cases by the immensely complicated and laborious computations needed.

The development of computationally practicable expressions for certain very difficult integrals (by Kotani in Japan, Coulson and Barnett at Oxford, Boys in Cambridge, Ruedenberg and Roothaan here, and others) has gone far recently toward breaking this computational bottleneck. A still more important new factor has been the programming for large electronic digital computers of the otherwise still excessively time-consuming numerical computation of these integrals. In our laboratory, machine programs have been completed for this purpose and for additional steps needed to obtain fairly good molecular wave functions for simple molecules. (Others elsewhere have also made substantial progress.)

With these wave functions available, various molecular properties can be computed, and fundamental understanding of molecular and solid structures and of intermolecular forces can be advanced immensely. Computations on radicals, ions, and excited and activated states of molecules, which often are experimentally little accessible, will be especially valuable. We in this laboratory are now working in these directions. We believe the investigators in this field have crossed the threshold of a new era in the application of quantum mechanics to molecular physics and quantum chemistry.

This work was assisted in part by contracts with the Office of Naval Research and the U.S. Air Force Office of Scientific Research and by a grant from the National Science Foundation.

R. S. Mulliken
C. C. J. Roothaan
University of Chicago

Perception Time and Evoked Potentials

The customary temporal measure of perception has been the duration of a stimulus necessary for perception. Another measure, designated *perception time*, is here proposed. A time-limiting method of restricting perception is employed. A 10-msec informational flash readily perceived on each presentation, when followed by a second, noninformational flash of brief duration (10 μsec), is blanked out if the second flash occurs within 25 to 30 msec. From 30 to 45 msec, perceptual blanking is only partial and by 50 msec the blanking flash no longer interferes with perception of the first flash. Four normal adult subjects all gave similar results; three intensities of the blanking flash representing relative values of 1, 2, and 8 all gave similar S-shaped curves of complete, partial, or no blanking, depending upon the duration between the onset of the first stimulus and the onset of the second. Absolute perception time would be the duration when blanking is complete; relative perception time that period when blanking is partial.

Perceptual blanking is believed to occur at the cortical level, when the arrival of impulse discharges from the second stimulus interfere with the consolidation processes of those from the first stimulus. The recording of evoked potentials from over the visual area of the brain provides data on latency, form, and duration of evoked potentials which tend to support the argument that perception time is a cortical phenomenon. Evoked potentials were reconstructed by an algebraic summation method from multiple oscillograms.

This work was supported by the Research and Development Division, Office of the Surgeon General, Department of the Army (DA-49-007-MD-722).

Donald B. Lindsley
William H. Emmons
University of California, Los Angeles

Geologic Significance of Accumulator Plants in Rock Weathering

Accumulator plants differ widely in the elements accumulated but have been studied chiefly for their capacity to pick up minor elements deleterious to agriculture. However, the ability of some plants to accumulate certain major elements, such as silicon, aluminum, manganese, and iron, has geologic implications. Many kinds of vegetation, especially in the tropics, contain several percent silica or alumina dry weight. Some 10 to 20 tons dry weight of new growth per acre is added each year above ground in tropical jungles, and the roots add several tons more. A forest of silica-accumulator plants averaging 2.5 percent silica and 16 tons dry weight new growth per year would extract about 2000 tons of silica per acre in 5000 years—equivalent to the silica in 1 acre-foot of basalt. Comparison of lateritic soils with parent rock suggests that a silica-accumulator jungle could convert basalt

into lateritic soil rapidly, geologically speaking. The silica in ground water increases with depth and time in contact with the rock, but vadose water seems inadequate to yield the silica required by such a jungle of silica-accumulator plants; biochemical factors must therefore cause much more rapid solution of silica. Although some organically derived silica may be recycled or added to ground water, nevertheless, in tropical regions with high rainfall, large amounts of siliceous organic debris must be swept off the forest floor into the drainage system. Plants that accumulate other elements may have geologic importance in developing other special soil types and in expediting the selective removal of certain elements.

T. S. LOVERING
U.S. Geological Survey, Denver

Isotope Separation in the Magneto-Ionic Expander

The one-fluid hydromagnetic equation of completely ionized gases [G. F. Chew, M. L. Goldberger, F. E. Low, *Proc. Roy. Soc. (London)* **A236**, 112 (1956)],

$$\rho\left(\frac{d\mathbf{u}}{dt}\right) = n_0 M\left(\frac{d\mathbf{u}}{dt}\right) = (-\operatorname{div}\overleftrightarrow{\mathbf{P}_0} + [\mathbf{j}\times\mathbf{B}]), \qquad (1)$$

may be modified for the case of two isotopic ions into two equations

$$n_1 M_1\left(\frac{d\mathbf{u}_1}{dt}\right) = (n_1/n_0)(-\operatorname{div}\overleftrightarrow{\mathbf{P}_0} + [\mathbf{j}\times\mathbf{B}]) \qquad (2)$$

$$n_2 M_2\left(\frac{d\mathbf{u}_2}{dt}\right) = (n_2/n_0)(-\operatorname{div}\overleftrightarrow{\mathbf{P}_0} + [\mathbf{j}\times\mathbf{B}]) \qquad (3)$$

where M_1, M_2 are the ionic masses and n_1, n_2 are the particle densities of the two isotopes. If $M_1 < M < M_2$ the values of the last parentheses in the right hand sides of Eqs. 1, 2, and 3 will differ at most in the ratio $\left(1 \pm \frac{\delta M}{M}\right)$, $\delta M = M_2 - M_1$ which we will regard as negligible.

Equations 2 and 3 yield the single equation

$$\left(\frac{d\mathbf{u}_2}{dt}\right) - \left(\frac{d\mathbf{u}_1}{dt}\right) = \frac{\delta M}{M}\frac{1}{\rho}(-\operatorname{div}\overleftrightarrow{\mathbf{P}_0} + [\mathbf{j}\times\mathbf{B}]) = \frac{\delta M}{M}\left(\frac{d\mathbf{u}}{dt}\right) \qquad (4)$$

Consider the magneto-ionic expander [J. Slepian, *J. Franklin Inst.* **263**, 129 (1957); *Nuclear Sci. and Eng.* **2**, 108 (1958)]. In the throat of the expander tube, n_1/n_2 is a constant. At an expander side wall one of the isotopes has a perpendicular component of acceleration equal to $\left(\frac{\partial l}{\partial y}\right)\mathbf{u}_y^2$ where l is the normal distance between the two expander plates taken at distance y on the expander plate from the arc. The other isotope will have a perpendicular component of acceleration equal to

$$\left(1 \pm \frac{\delta M}{M}\right)\left(\frac{\partial l}{\partial y}\right)\mathbf{u}_y^2$$

The displacement of the precipitating isotopic ions upon the slats will therefore vary as the square of the length of the expander wall.

Calculation thus yields for a 100-amp uranium arc a cost of \$8 per gram of U^{235}, and for a 1000-amp arc a cost of \$2. The cost per gram of U^{235} by the present diffusion method is more than \$15.

JOSEPH SLEPIAN
Pittsburgh, Pennsylvania

Protein Biosynthesis by a Cell-Free Bacterial System

A particulate fraction from sonically disrupted cells of *Alcaligenes faecalis* incorporates C^{14}-labeled L-amino acids into protein. The incorporation of one is stimulated by addition of the unlabeled 18 remaining amino acids and is inhibited by chloramphenicol. Small net increases in protein nitrogen (up to 20 percent) have been observed. The system appears to depend on oxidative phosphorylation for generation of the adenosine triphosphate (ATP) required for amino acid activation.

After the particles have been washed with 1.0*M* NaCl, amino acid incorporation is markedly depressed. Reactivation can be effected by addition of ribonucleic acid or by addition of an enzyme present in the original supernatant fluid. After several hundredfold purification, this enzyme can restore the activity of the washed particles at concentrations of 2 to 3 μg of protein per milliliter of reaction mixture and is active in stimulating the incorporation of all the labeled amino acids so far investigated—that is, glycine, alanine, threonine, valine, leucine, lysine, proline, phenylalanine, tyrosine, and tryptophan.

Neither the purified soluble enzyme nor the washed particles (whether intact or disintegrated by further sonic treatment) contain activating enzymes catalyzing the exchange of P^{32}-labeled pyrophosphate with ATP in the presence of amino acids. Such enzymes are present in the initial extract and at some stages of purification but are absent from the purest fractions of the amino acid incorporation enzyme. The new enzyme is not involved in the oxidative phosphorylation carried out by the particles and appears to be concerned with some phase of protein biosynthesis.

SEVERO OCHOA, MIRKO BELJANSKI
New York University College of Medicine

Infant Mortality Rates and Poliomyelitis: An Epidemiological Study

An increasing body of information indicates that where sanitary conditions are substandard, poliomyelitis is generally reported as an *endemic* disease of infants with low case incidence rates. In some contrast is the pattern in countries with the highest sanitary standards, where the incidence is greater, the disease generally appears in the form of periodic epidemics, and the patients are of school age or older. A recognized index of such sanitary standards is the local *infant mortality* rate (that is, the number of infant deaths per 1000 live births). This may vary from country to country with a range of from 150 or more to less than 30. Several analyses have been made of the inverse ratio of infant mortality rates to poliomyelitis case incidence, and such analyses, although they involve many variables, exhibit fairly consistent trends, one feature being that as infant mortality declines from 100 to about 75, local epidemics of poliomyelitis begin to appear.

The present report is concerned with data obtained through the Pan American Sanitary Bureau from North, South, and Central American countries during the period 1940–1955. In some of these countries the epidemiologic picture has changed during this period from old fashioned endemic "infantile paralysis" to the periodic scourge of modern "polio." Attempts are made in this study to determine the degree to which the afore-mentioned ratios hold in Pan America, and whether one can predict when and where modern "polio" will appear in Central and South America.

JOHN R. PAUL
Yale University School of Medicine

Comparison between Mutation Rates Induced by Chronic Gamma and Acute X-irradiation in Mice

Extensive data are being collected on the induction of specific locus mutations in mice exposed to chronic gamma radiation from Cs^{137}. Results already obtained from an accumulated dose of 600 r given to spermatogonia at approximately 10 r/wk continuous irradiation show a much lower mutation rate than that obtained earlier with a 600-r acute dose of x-rays. In view of the nature of the material, which consists of cells undergoing rapid cycles of mitosis, it cannot be assumed that mutation rate will prove to be linearly related to dose or even that the shape of the dose curve will be the same as that obtained with x-rays, which itself shows a departure from linearity. Therefore, it would be incautious to assume that the same difference between x-rays and gamma rays will be found at lower doses or lower dose rates. The information obtained from a gamma radiation dose of 100 r given at approximately 10 r/wk is not yet adequate to settle this point. It does, however, already provide a reassuring answer to the more extreme possibility arising from the nonlinearity of the x-ray data that the mutation rate at low doses or low dose rates might actually be higher than that calculated by interpolation between the control rate and the rate from high acute x-ray doses. Even the upper 95 percent confidence limit for the induced mutation rate in this 10-r/wk 100-r experiment does not exceed the interpolated rate by more than a factor of two.

W. L. RUSSELL
ELIZABETH M. KELLY
Oak Ridge National Laboratory

The Earth's Crust

It has been firmly established that the earth's crust is approximately 35 km thick under the continental shield areas and 5 km thick under ocean basins. Anomalous parts of the crust, such as mountain regions, are now receiving special attention. Three methods of investigation are being used: (i) gravity variations, (ii) explosion seismology, and (iii) variations in the phase velocity of earthquake-generated surface waves. Methods i and iii give concordant results which may best be interpreted in terms of compensation of high topography by regional crustal thickening. Method ii seems to support this interpretation in some regions, such as the Soviet Union, and gives contradictory results in other regions such as the western United States. An attempt is made to reconcile these divergent results. It is concluded that a higher degree of precision in explosion seismology is required, particularly in identifying later arriving seismic waves by correlation methods, in order to delineate velocity variations within the crust.

FRANK PRESS
California Institute of Technology

Neutrino Theory of Gravitation

This paper is a preliminary report on an attempt to account for gravitation by means of a quantized neutral, massless field, which is coupled to the energy density of matter, the electromagnetic field, and all strong and electromagnetic interactions. The quanta of the gravitational field may consist of spin zero particles, or of neutrino-antineutrino pairs. The theory has no relation to the general theory of relativity, which is successful in accounting for the five known experimental phenomena but is difficult to quantize. The present theory accounts for three of these phenomena: the Newtonian inverse-square law of attraction between distant masses, the precise proportionality between gravitational and inertial mass demonstrated by Eötvös, and the red shift of light originating in a strong gravitational field. The other two phenomena, the deflection of light passing through a strong gravitational field, and the advance of the perihelion of the orbit of the planet Mercury, are predicted to have half their observed values. In its present form the theory is not Lorentz-invariant; it is being modified in the hope of making it Lorentz-invariant and improving agreement with observation.

L. I. SCHIFF
Stanford University

Lytic and Reproduction-Inhibiting Antibodies against Trypanosoma lewisi

Both ablastin that inhibits the reproduction of *Trypanosoma lewisi* early in the infection in the rat and the lysin that terminates the infection localize in the gamma-1 or T fraction during electrophoresis. Ablastin is a small molecule ($S_{20}=6S$), whereas the lysin is large ($S_{20}=16S$). Ablastin, first described by Taliaferro [*J. Exptl. Med.* **39**, 171 (1924)], specifically inhibits mitosis and cell division of the trypanosomes with no apparent effect on general vitality, motility, or infectivity. Moulder [*J. Infectious Diseases* **83**, 42 (1948)] found that the inhibition by ablastin shifted the carbohydrate metabolism from a state of active assimilation to one of maintenance. We have found that dividing trypanosomes incorporate 3 to 4 times as much S^{35}-labeled amino acids into their TCA-insoluble fraction as do inhibited parasites. Dividing trypanosomes incorporate relatively large quantities of adenine-8-C^{14} sulfate into their TCA-insoluble fraction, whereas inhibited parasites incorporate practically none. The results indicate that the parasites inhibited by ablastin are forming no nucleic acid and very little protein.

WILLIAM H. TALIAFERRO,
TULIO PIZZI, PHILIP D'ALESANDRO
University of Chicago

Some Observations on the Abundance of the Elements

An estimate of the abundances of the elements made by Suess and Urey has been used by Fowler *et al.* and Cameron as a basis for theories for the origin of the elements in the interior of stars. However, they used abundances in the neighborhood of iron and in the lead-uranium regions taken from astronomical data. A study has been made to see whether any likely chemical separation would result in errors in the meteoritic abundances of sufficient magnitude to account for the difference in data of these two sources. It is concluded that the meteoritic data very probably represent one cosmic composition. No systematic chemical separations have been discovered which would lead to errors in these particular elements and not in others. A considerable variation in the abundance of primitive lead in various chondrites suggests that some loss of lead may have occurred. Because of this, as well as analytical difficulties, it may be presumed that the abundance of lead in meteorites is not well known, but no such uncertainty exists in the cases of uranium and thorium. If the solar abundances are correct, then it is concluded that the source of elements in the meteorites and the sun have not been the same or that differences in abundances have been produced during the history of the solar system. Theories for the origin of the elements should be able to account for the meteoritic abundances.

HAROLD C. UREY
University of Chicago

Infrared Spectra of Symmetrical Molecules under High Resolution

A grating spectrometer has been designed which achieves high resolution in the region from 2 to 5 μ. This region is measured with two gratings of 15,000 lines/in. and 10,000 lines/in. A resolution of about 0.03 cm^{-1} is obtained throughout the region, and lines separated by 0.024 cm^{-1} have been resolved at 3.6 μ. Infrared bands of methane, ethylene, and ethane have been measured, and each line of the *P* and *R* branches is resolved into several components. From the observed spectra more precise values of the molecular constants can be obtained. Illustrations of the observed spectra will be shown.

EARLE K. PLYLER
National Bureau of Standards

COMPUTATION AND DATA REDUCTION

Systems engineering for the Air Force Ballistic Missile Program requires the extensive utilization of high speed digital computers. Space Technology Laboratories has one of the largest and most advanced computing facilities in the nation, including two large-scale scientific digital computers, a 300- amplifier analog computer, a 30-channel analog-to-digital converter, and a specially designed data reduction center for analysis of telemetry.

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Letters

Mendeliana

I should like to comment on the news paragraph headed "Mendeliana" [*Science* **127**, 77 (1958)]. The facts are that the monastery in Brno, Czechoslovakia, where Mendel lived and where the museum was, got a direct hit in the Allied bombing in 1945 and a good many Mendeliana were destroyed. However, when I visited Brno in 1947, they were rebuilding the monastery and had a temporary exhibition of Mendeliana. The implication that the Czechs were not interested in preserving records of Mendel is quite false, even though in 1947 (not now) Mendel-Morganism was definitely frowned upon.

When I was in Brno I was on my own and was fortunate in finding an English-speaking curator at the folk museum who took me to the Mendel museum. I quote what I actually wrote in my diary at the time: "An Augustine monk who spoke no English met us and shewed us round. I was terribly disappointed to find that Mendel's experimental plot was now a rather unkempt flower garden, with a monument commemorating his birth centenary, 1822–1922 (inscribed in English as well as other languages). The priest shewed us some beans growing on a rubbish dump which he *said* were direct descendents of Mendel's beans! . . . I was intrigued [in the museum] by Mendel's bed (he died on his settee while sitting up)—a lovely walnut one, with side pieces like Norwegian beds. Hank [the folk museum curator] had never seen a bed with side pieces before. It did not look the kind of hard bed you would expect of a monk. He [Mendel] was not a very good plant presser" (this referred to the very poorly pressed herbarium of Mendel's which was on display with, so far as I can remember now—I haven't recorded it—some magnifying lens or simple microscope).

It is 11 years already since I was there; the whole of Brno still had a very bombed look, and I do not think Mendeliana were any more neglected than anything else at that time. It must be remembered that Brno was a very German town and was going through a difficult period. Another English biologist, who visited Brno in 1954, tells me that when she went, she found the monastery now closed (I believe that there were only eight monks when I was there) and the Mendeliana housed in a special museum. I hope that someone from the University of Illinois will find the opportunity to make contact with whosoever is in charge of the Mendel Museum in Brno.

AMICIA M. YOUNG

London, England

Sex Determination

A recent paper by M. Gordon [*Proc. Natl. Acad. Sci. U.S.* **43**, 913 (1957)] mentioned in "News of Science" [*Science* **126**, 1059 (1957)] puts forward a claim of success in separating the two kinds of sperm, reporting data for 31 litters of rabbits. These data contain a peculiar heterogeneity which should be noticed. In all cases, sexing involved examination of the gonads; for the last 13 litters the accessory organs also were examined. The results for these last 13 litters differ from the first 18, with respect to the *difference* between sex ratios when males were expected and when females were expected, being statistically significant beyond the level of 1 in 1000. Among the last 13 litters there is obviously no significant effect of electrophoresis, the sex ratio being 17 males to 22 females when males were expected and 16 males to 29 females when females were expected (nor is this changed by excluding the three litters for which "incorrect technique was suspected. . . .").

No explanation of this difference which is compatible with all the reported circumstances suggests itself. For the time being, therefore, three possibilities appear equally admissible: (i) electrophoresis is ineffective, but accidents of sampling or unknown factors produced a strong appearance of effect in the first 18 litters; (ii) electrophoresis is effective, but accidents of sampling almost totally obscured the effect in the last 13 litters; or (iii) electrophoresis is effective in some circumstances not yet defined. Obviously it is premature to select one of these three rather than another.

Any a posteriori analysis of data will raise in some minds the question of whether the tests of significance performed, and, more important, those reported, were suggested by the data themselves and, hence, whether the significance levels are misleading. My approach was really a priori in that I sought heterogeneity at each change of technique, and I mention in passing that changing after 8 litters to "blind" sexing for the next 10 litters did not alter the difference observed between the two sex ratios.

H. W. NORTON

College of Agriculture,
University of Illinois, Urbana

Founder of Hydrographic Office

It is not correct to state, as Hugh Odishaw does [*Science* **127**, 124 (1958)] that Matthew F. Maury was "the founder of the U.S. Navy Hydrographic Office." Strictly speaking, the Hydrographic Office was established by Act of Congress of 21 June 1866 (14 Stat. L. 69), and it

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first head was Commander T. S. Fillebrown, U.S.N. Maury had left the Federal for the Confederate Navy in 1861, before the creation of the Bureau of Navigation, whose founder, Rear Admiral Charles H. Davis, U.S.N., was probably the instigator of the movement for a Hydrographic Office.

In a wider sense, the Hydrographic Office started in 1830 with the establishment of the Navy's Depot of Charts and Instruments, since the depot was split in 1866 into the Hydrographic Office and the Naval Observatory. It is not correct to speak of Maury as "the founder of the Naval Depot of Charts," as do A. Joseph Wraight and Captain Elliott B. Roberts of the U.S. Coast and Geodetic Survey [*The Coast and Geodetic Survey 1807–1957* (U. S. Government Printing Office, Washington, D.C., 1957), p. 22]. The depot's founder and first head was Lieutenant Louis M. Goldsborough, U.S.N. His successors (all of the same rank) were Charles Wilkes, James M. Gilliss, and Matthew F. Maury. Upon Maury's departure in 1861, he was succeeded by Gilliss.

Maury was unquestionably the best known as head of the depot, and these remarks are intended not to depreciate his deservedly outstanding reputation but to correct recent mistakes in the historical record, mistakes whose currency might lead to the distortion of accomplishments too noteworthy to need enlargement.

HAROLD L. BURSTYN

London, England

As authors of *The Coast and Geodetic Survey, 1807–1957,* we are glad to acknowledge the factual accuracy of the statements made in Harold L. Burstyn's letter. We would like to point out, however, that our publication is a brief review, intended to convey general ideas without pretentions of definitive accuracy. The reference to M. F. Maury was based upon the officially recognized facts that he was the first officer of the Depot of Charts and Instruments to engage in the scientific study of physical oceanography, including winds, weather, and currents, and the first to engage the collaboration of ship masters in assembling data important in navigation. He, in fact, fathered the basic ideas upon which the U.S. Navy Hydrographic Office was developed. Our statement, therefore, seems to us correct in its significance though not literally true.

A. J. WRAIGHT
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U.S. Coast and Geodetic Survey, Washington, D.C.

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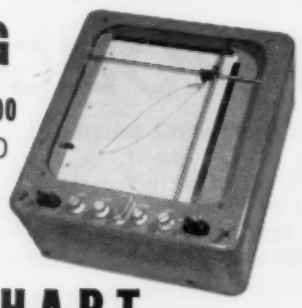

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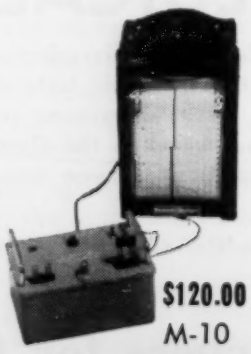

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Meetings

Geochemical Society

The Geochemical Society was organized at a meeting in New Orleans in November 1955, for the purpose, as stated in its constitution, of "encouraging the application of chemistry to the solution of geological and cosmological problems." Its membership is international, at the present time including more than 1500 members from 50 different countries. Membership is open to anyone who will subscribe to the purpose of the society and who has either (i) training equivalent to at least a bachelor's degree in physical science, biological science, mathematics, or engineering or (ii) three years' experience in any one of these disciplines. The membership roll includes, besides geochemists, representatives from a wide variety of fields, ranging from astrophysics to ceramics, oceanography, and paleontology.

Annual meetings are held, whenever practicable, at the same time and place as the meetings of the Geological Society of America. Additional meetings, in the United States or elsewhere, may be called by the council of the society. For example, the society held a joint session with the Commission on Geochemistry of the International Union of Pure and Applied Chemistry, in Paris, in July 1957.

The Geochemical Society is affiliated with many scientific organizations throughout the world; its most recent affiliation is with the American Association for the Advancement of Science. It is a member of the American Geological Institute and of the Division of Chemistry and Chemical Technology and the Division of Earth Sciences of the National Research Council.

The official publication of the society is *Geochimica et Cosmochimica Acta*, published by the Pergamon Press; members of the society are eligible to receive this journal at the special price of $10.00 per year. A newsletter, *Geochemical News*, is published bimonthly by the society.

A current project of the society is the translation of the Russian journal *Geokhimiya*, an undertaking to be subsidized by a grant from the National Science Foundation. If this project is successful, translations of other Russian journals and books on geochemistry will be undertaken. Other current activities include efforts to improve and broaden education in geochemistry and to encourage geochemical investigations through a research committee. The society hopes ultimately to be able to further geochemical research by awards and grants-in-aid and to set up standards for analytical work on geochemical problems.

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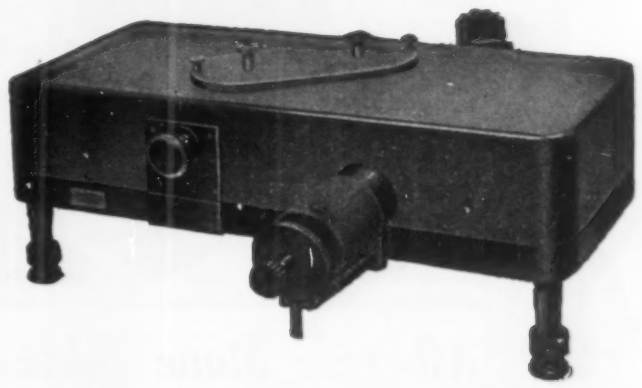

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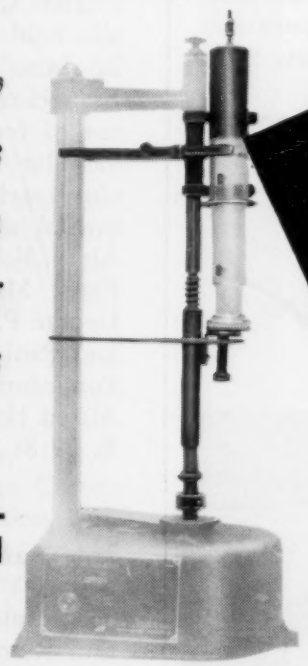

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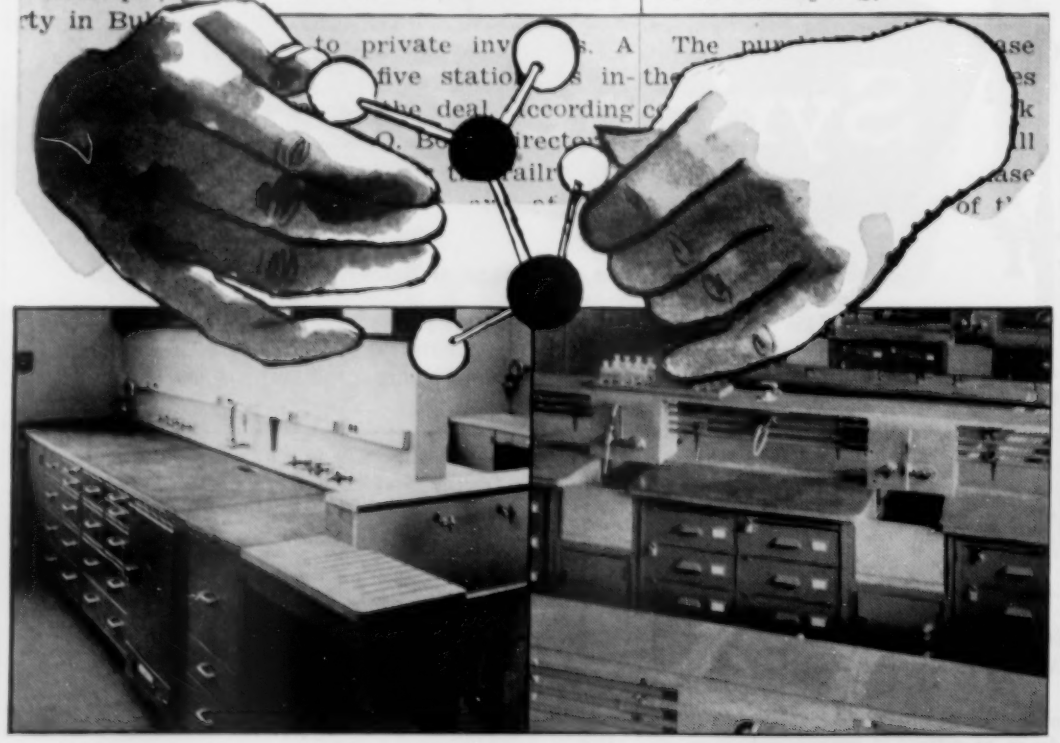

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International Botanical Congress

The ninth International Botanical Congress will be held in Montreal, Canada, from 19 to 29 August 1959 at McGill University and the University of Montreal. The program will include papers and symposia related to all branches of pure and applied botany. The 10-day meeting will be one of the biggest scientific gatherings ever to take place in Canada. Some 4000 participants are expected from all parts of the world.

W. P. Thompson, president of the University of Saskatchewan, has been named president of the congress. Thompson is internationally known for his work on the genetics of cereals, especially wheat. For information write to the secretary–general, Dr. C. Frankton, IX International Botanical Congress, Science Service Building, Ottawa, Ontario, Canada.

American College of Angiology

The American College of Angiology will hold its fourth annual meeting, 21–22 June, at the Fairmont Hotel, San Francisco, Calif. The meeting will consist of four sessions devoted to cardiovascular surgery, cardiovascular medicine, cerebrovascular disease, and experimental angiology. The cochairmen are Alvin Bakst, Brooklyn, N.Y.; J. Earle Estes, Mayo Clinic, Rochester, Minn.; George P. Fulton, San Francisco, Calif.; and Paul S. Lowenstein, St. Louis, Mo. For information, communicate with Dr. Alfred Halpern, Executive Secretary, 15 E. 62 St., New York 21, N.Y.

International Radiation Congress

An International Congress of Radiation Research will be held at the University of Vermont, Burlington, 10–16 August, under the joint sponsorship of the National Academy of Sciences–National Research Council and the Radiation Research Society in cooperation with the European Committee on Radiobiology. The congress is being organized in order to provide an international forum for an interdisciplinary attack on the broad area of radiation research.

Under the chairmanship of the congress president, Alexander Hollaender of Oak Ridge National Laboratory, the organizing committee has scheduled the

following symposia: 12 Aug., "Role of oxygen and peroxides in radiation chemistry: Analysis and correlation of various radiobiological actions on the same cell species (yeast)"; 13 Aug., "Free radicals produced by irradiation"; 14 Aug., "Late effects of irradiation in mammals"; 15 Aug., "Induced changes in deoxyribonucleic acid and in chromosome structure." In addition, plenary sessions have been planned on the progress and status of radiation research, and ample opportunity will be given those who wish to present contributed papers in the broad area of radiation research. Information concerning the presentation of papers, registration, and housing may be obtained from Dr. Harvey M. Patt, Secretary General, International Congress of Radiation Research, Argonne National Laboratory, Post Office Box 299, Lemont, Ill.

Society Elections

■ American Dental Association: pres., William R. Alstadt, Little Rock, Ark.; pres.-elect, Percy T. Phillips, New York, N.Y.; sec., Harold Hillenbrand, 222 E. Superior St., Chicago, Ill.; treas., H. B. Washburn, St. Paul, Minn. The vice presidents are Arthur W. Kellner, Hollywood, Fla.; J. Murray Gavel, Boston, Mass.; Bruce F. Wilkinson, Tyler, Tex. The assistant secretaries are C. Willard Camalier, Washington, D.C., and Louis M. Cruttenden, Chicago, Ill. The representative to the AAAS Council is H. Trendley.

■ Sigma Delta Epsilon: pres., and representative to the AAAS Council, Mary Louise Robbins, George Washington Medical School, Washington, D.C.; sec., Helen Borton Parker, 7 Lloyd Road, Malvern, Pa.; treas., Teresa Cohen, Pennsylvania State University. The vice presidents are Esther S. Anderson, Department of Geography, University of Nebraska, and Ethaline Cortelyou, Armour Research Foundation, Chicago, Ill. The representative to the AAAS Council is Irene Corey Diller, Institute for Cancer Research, Philadelphia, Pa.

■ Western Society of Engineers: pres., George L. Jackson, Illinois State Toll Highway Commission; treas., Hjalmar W. Johnson, Inland Steel Company; executive sec., J. Earl Harrington, 84 East Randolph St., Chicago 1, Ill. The past presidents are John F. Sullivan, Jr., Asbestos and Magnesia Materials Company, and Albert P. Boysen, U.S. Steel Company. The vice presidents are Ormas G. Smith, Illinois Bell Telephone Company, and William A. Marston, Chicago, Ill.

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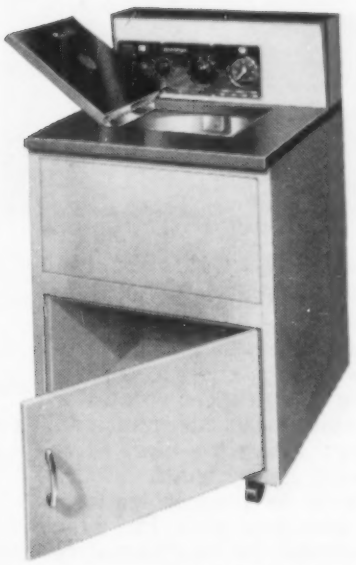

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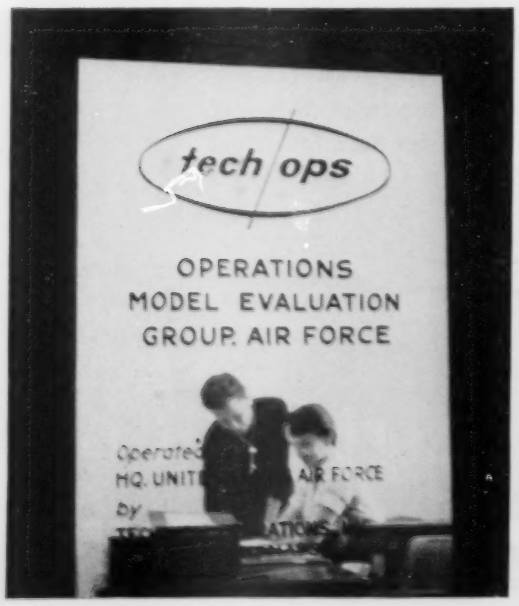

■ American Sociological Society: pres., Robin M. Williams, Jr., Department of Sociology and Anthropology, Cornell University; v. pres., Robert E. L. Faris, Department of Sociology, University of Washington; pres.-elect, Kingsley Davis, University of California; past pres., Robert K. Merton, Department of Sociology, Columbia University; sec., Wellman J. Warner, Department of Sociology, New York University, N.Y.

Forthcoming Events

June

2–4. Telemetering Conf., 6th natl., Baltimore, Md. (G. M. Thynell, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.)

2–5. American Nuclear Soc., 4th annual, Los Angeles, Calif. (ANS, P.O. Box 963, Oak Ridge, Tenn.)

2–6. Mass Spectrometry, 6th meeting, New Orleans, La. (R. A. Friedel, U.S. Bureau of Mines, 4800 Forbes St., Pittsburgh 13, Pa.)

2–6. Medical Library Assoc., 57th annual, Rochester, Minn. (T. E. Keys, Librarian, Mayo Clinic, Rochester.)

2–6. Peaceful Uses of Atomic Energy in Australia, symp., Sydney, N.S.W. (Australian Atomic Energy Commission Research Establishment, Private Mail Bag, Sutherland, New South Wales.)

2–7. Industrial Microbiological Inst., 11th annual, Lafayette, Ind. (C. L. Porter, Stanley Coulter Hall, Purdue Univ., Lafayette.)

2–7. Mechanical Engineering, 7th internatl. cong., Scheveningen, Netherlands. (International Mechanical Engineering Cong., 10 avenue Hoche, Paris 8e.

3–5. Special Libraries Assoc., annual, Chicago, Ill. (M. E. Lucius, SLA, 31 E. 10 St., New York 3.)

4–14. Large Electric Systems, 17th intern. conf., Paris, France. (112, Boulevard Haussmann, Paris.)

5. Institute of Microbiology, 4th annual, New Brunswick, N.J. (E. R. Isaacs, Inst. of Microbiology, Rutgers Univ., New Brunswick.)

9–11. American Assoc. of Spectrographers, 9th annual symp., Chicago, Ill. (H. J. Hettel, Armour Research Foundation, 10 W. 35 St., Chicago 16.)

9–11. Canadian Federation of Biological Societies, 1st annual; with Canadian Assoc. of Anatomists, Canadian Biochemical Soc., Canadian Physiological Soc., and Pharmacological Soc. of Canada; Kingston, Ontario. (E. H. Bensley, Montreal General Hospital, 1650 Cedar Ave., Montreal 25, P.Q.)

9–11. Health Physics Soc., 3rd annual, Berkeley, Calif. (E. E. Anderson, Oak Ridge National Lab., Oak Ridge, Tenn.)

9–11. Soc. of General Physiologists, Woods Hole, Mass. (F. G. Sherman, Dept. of Biology, Brown Univ., Providence 12, R.I.)

9–11. Society for the Study of Development and Growth, 17th annual symp., South Hadley, Mass. (Miss K. Stein, Dept. of Zoology, Mount Holyoke College, South Hadley.)

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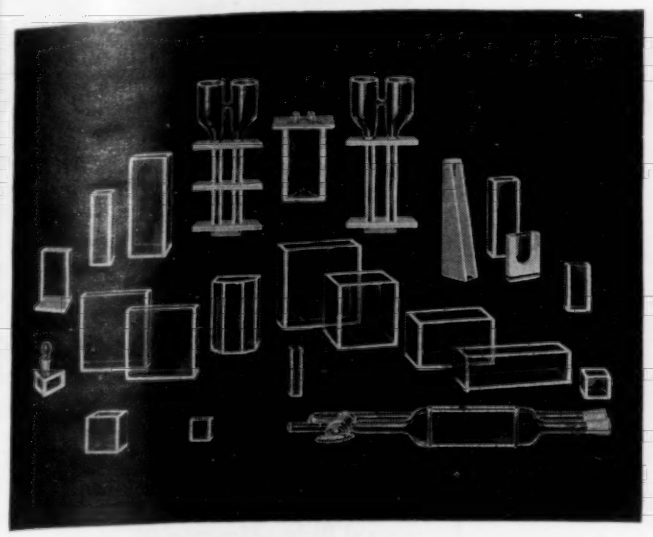

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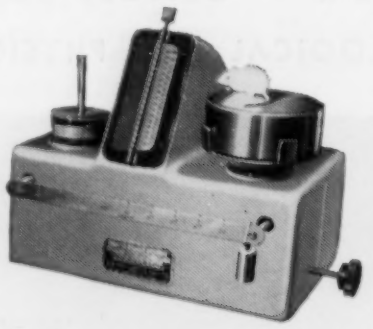

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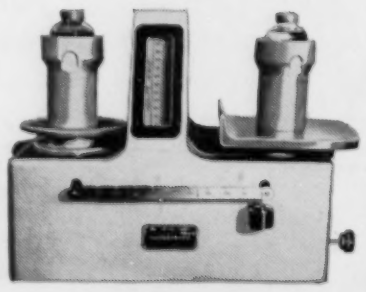

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10–12. Astronomical Soc. of the Pacific, annual, Los Angeles, Calif. (S. Einarsson, Leuschner Observatory, Univ. of California, Berkeley 4.)

10–13. Vacuum Techniques, 1st internatl. congress, Namur, Belgium. (R. Thomas, c/o CSN/ERM, 30, avenue de la Renaissance, Brussels 4, Belgium.)

11–14. Applied Mechanics, 3rd natl. Cong., Providence, R.I. (W. Prager, Brown Univ., Providence 12.)

11–14. National Soc. of Professional Engineers, St. Louis, Mo. (P. H. Robbins, NSPE, 2029 K St., NW, Washington, D.C.)

14–21. American Soc. of Medical Technologists, annual, Milwaukee, Wis. (Miss R. Matthaei, Suite 25, Hermann Professional Bldg., Houston 25, Tex.)

15–19. American Soc. of Mechanical Engineers, semiannual, Detroit, Mich. (O. B. Schier, II, ASME, 29 W. 39 St., New York 18.)

15–19. Cancer Research Conf., 3rd Canadian, Honey Harbour, Ontario. (R. L. Noble, Collip Medical Research Lab., Univ. of Western Ontario, London, Ont., Canada.)

15–20. American Physical Therapy Assoc., annual, Seattle, Wash. (Miss M. E. Haskell, APTA, 1790 Broadway, New York 19.)

16–18. American Neurological Assoc., 83rd annual, Atlantic City, N.J. (C. Rupp, 133 S. 36 St., Philadelphia 4, Pa.)

16–18. Military Electronics Conv., 2nd, Washington, D.C. (G. Rappaport, Emerson Radio & Phonograph Corp., 114 East-West Highway, Silver Spring, Md.)

16–18. Photochemical Apparatus Symp., Upton, N.Y. (R. C. Fuller, Biology Dept., Brookhaven National Laboratory, Upton, L.I.)

16–20. American Soc. for Engineering Education, annual, Berkeley, Calif. (W. L. Collins, Univ. of Illinois, Urbana.)

16–20. Association of Official Seed Analysts, annual, Montreal, Quebec, Canada. (L. C. Shenberger, Seed Lab., Dept. of Agricultural Chemistry, Purdue Univ., Lafayette, Ind.)

16–20. Molecular Structure and Spectroscopy Symp., Columbus, Ohio. (R. A. Oetjen, Dept. of Physics and Astronomy, Ohio State Univ., Columbus 10.)

16–20. Pacific Div., AAAS, annual, Logan, Utah. (R. C. Miller, California Acad. of Sciences, Golden Gate Park, San Francisco 18.)

17–19. American Dairy Science Assoc., annual, Raleigh, N.C. (H. F. Judkins, 32 Ridgeway Circle, White Plains, N.Y.)

17–19. American Meteorological Soc., with Pacific Div., AAAS, Logan, Utah. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

18–20. Statistical Methods in Radio Wave Propagation, intern. symp., Los Angeles, Calif. (W. C. Hoffman, 3116 Engineering Bldg., Univ. of California, Los Angeles 24.)

18–21. College Physicists, 20th annual colloquium, Iowa City, Iowa. (J. A. Van Allen, Dept. of Physics, State Univ. of Iowa, Iowa City.)

18–22. American College of Chest Physicians, annual, San Francisco, Calif. (M. Kornfeld, ACCP, 112 E. Chestnut St., Chicago 11, Ill.)

19–21. Endocrine Soc., 40th annual, San Francisco, Calif. (H. H. Turner, 1200 N. Walker St., Oklahoma City 3, Okla.)

19–21. Society of Nuclear Medicine, 5th annual, Los Angeles, Calif. (R. W. Lackey, 452 Metropolitan Bldg., Denver, Colo.)

19–25. Scandinavian-American Meteorological Meeting, Bergen, Norway. (K. C. Spengler, 3 Joy St., Boston, Mass.)

21–22. Society for Investigative Dermatology, annual, San Francisco, Calif. (H. Beerman, 255 S. 17 St., Philadelphia 3, Pa.)

22–25. American Soc. of Agricultural Engineers, 51st annual, Santa Barbara, Calif. (J. L. Butt, ASAE, St. Joseph, Mich.)

22–27. American Inst. of Chemical Engineers, 50th anniversary, Philadelphia, Pa. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

22–27. American Soc. for Testing Materials, 61st annual, Boston, Mass. (F. F. Van Atta, ASTM, 1916 Race St., Philadelphia 3, Pa.)

23–24. Unstable Chemical Species Symp., Los Angeles, Calif. (Directorate of Advanced Studies, Air Force Office of Scientific Research, P. O. Box 2035-D, Pasadena, Calif.)

23–25. American Soc. of Heating and Air-Conditioning Engineers, semiannual, Minneapolis, Minn. (A. V. Hutchinson, ASHAE, 62 Worth St., New York 13.)

23–25. American Soc. of Refrigerating Engineers, annual, Minneapolis, Minn. (R. C. Cross, ASRE, 234 Fifth Ave., New York 1.)

23–27. American Soc. of Civil Engineers, Portland, Ore. (W. H. Wisely, ASCE, 33 W. 39 St., New York 18.)

23–28. Low Temperature Physics, 6th internatl. conf., Leiden, Netherlands. (J. van den Handel, Kamerlingh Onnes Laboratory, Leiden.)

24–26. Carcinogenesis: Mechanisms of Action, Ciba Foundation symp. (by invitation), London, England. (G. E. W. Wolstenholme, 41 Portland Pl., London, W.1.)

24–27. American Home Economics Assoc., annual, Philadelphia, Pa. (Miss M. Horton, AHEA, 1600 20 St., NW, Washington 9.)

25–28. American Assoc. of Physics Teachers, Boulder, Colo. (F. Verbrugge, School of Physics, Univ. of Minnesota, Minneapolis.)

25–1. International Soc. of Urology, 11th, Stockholm, Sweden. (G. Giertz, Karolinska Sjukhuset, Stockholm C.)

29–2. American Astronomical Soc., Madison, Wis. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

29–4. National Education Assoc., Cleveland, Ohio. (W. G. Carr, NEA, 201 16 St., NW, Washington 6.)

(*See issue of 18 April for comprehensive list*)

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Equipment

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■ FLASH-POINT INDICATOR for the range 80° to 180°F is automatic in operation. Results do not vary more than ±2°F from those obtained manually. Repeatability is within ±1°F. Test time is 2 to 4 min. (Precision Scientific Co., Dept. 20)

■ COPYING MACHINE accepts originals up to 8½ by 11 in. and produces up to five copies from one negative. The device is a simplified compact version of previous models. (Eastman Kodak Co., Dept. 9)

■ DOUBLE-BEAM POLARIZER for the manufacturer's H-800 infrared spectophotometer uses selenium films in transmission, which act as plane polarizers when the incident beam is inclined at the Brewster angle. Efficiency of the polarizer varies with wavelength but is always better than 96 percent. (Hilger and Watts Ltd., Dept. 32)

■ HIGH-VOLTAGE POWER SUPPLIES deliver 10 kv d-c at 1.25 ma with r.m.s. ripple of 0.25 percent at 60 cy/sec or 0.04 percent at 400 cy/sec. The supplies feature reversible polarity; they are embedded in epoxy resin and are hermetically sealed. Dimensions are 3 by 3.5 by 5.5 in. (Del Electronics Corp., Dept. 18)

■ COMPUTER-LANGUAGE TRANSLATOR converts magnetic tapes recorded in the format required by one computer to that required by another computer. The equipment can also transfer data from punched cards or punched paper tape to magnetic tape and from magnetic tape to punched cards, paper tape, or line printer. Internal parity-checking, marginal-checking, and error-control features are provided. (Electronic Engineering Co., of California, Dept. 21)

■ CRYSTAL FILTERS provide four bandwidths at center frequency of 10.7 Mcy/sec. Bandwidths for 6 db are 30, 15, 6 and 3.5 kcy/sec. Specifications include shape factor of 2 to 1, insertion loss approximately 1 db, and size 2⅜ by 1 by 1 3/32 in. (Hycon Eastern, Inc., Dept. 19)

■ OSCILLOSCOPE CAMERA operates at a rate of one frame per second. Film size is 35 mm with capacity of 60 exposures in one loading. The instrument uses a 25-mm *f*1.9 lens or a 40 mm *f*1.5 lens. Resolution up to 90 lines/min is achieved. (OPTOmechanisms Inc., Dept. 22)

■ CONSTANT-CURRENT POWER SUPPLY switches over automatically to constant-voltage operation when the output voltage reaches a preselected value as a result of build-up of load resistance. Output current is adjustable from 0 to 2 amp, output voltage from 0 to 100 v. (Matthew Laboratories, Dept. 23)

■ SHEET-METAL LAYOUT MACHINE permits rapid placement of holes in chassis fabrication. Positioning of the drill-head accomplished by means of crank-operated counters on *x*- and *y*-axes, is accurate to 0.002 in. in 18 in. A foot-operated switch actuates the drilling of pilot holes. (OPTOmechanisms Inc., Dept. 25)

■ CHROMATOGRAPHY CABINET contains four solvent assemblies accommodating 8 sheets of 18¼- by 22½-in. paper. The cabinet is Formica-lined, insulated with glass wool, and provided with a triple-pane window for observation. (Research Specialties Co., Dept. 28)

■ HYGROTHERMOGRAPH operates over the relative-humidity range 15 to 95 percent at temperatures from 32° to 130°F. Humidity measurements are repeatable within ±3 percent RH. Temperature

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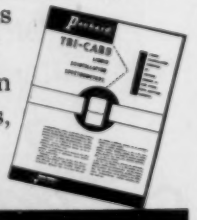

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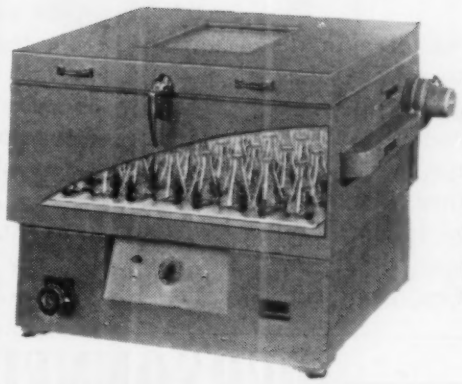

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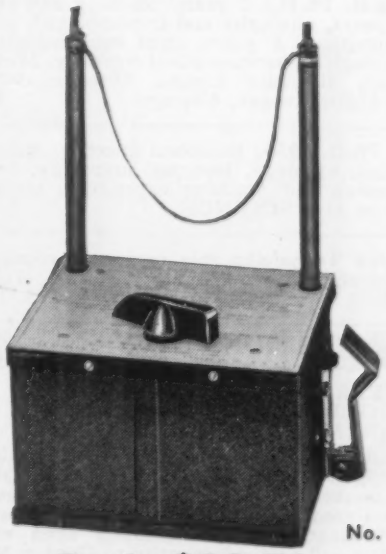

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